In a hope of Tomorrow's Future: Water Stewardship Plan for Godrej plant catchment at Nashik

Report of research study at
Godrej Agrovet. Ltd catchment in Dindori, Nashik

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Abbreviations

AWS	Alliance for Water Stewardship
CGWB	Central Ground Water Board
CRA	Climate Resilient Agriculture
CSR	Corporate Social Responsibility
DMIC	Delhi Mumbai Industrial Corridor
IWMP	Integrated Watershed Management Program
FGD	Focused Group Discussion
FPO	Farmer Producers Organisation
GAA-EL	Global Agribusiness Action on Equitable Livelihoods
GEC	Groundwater Estimation Committee
MSAPCC	Maharashtra State Action Plan on Climate Change
MGNREGA	Mahatma Gandhi National Rural Employment Guarantee Scheme
GIS	Global Information System
GPS	Global Positioning System
GoM	Government of Maharashtra
GP	Gram Panchayat
GSDA	Groundwater Survey and Development Agency
LULC	Land Use Land Cover
MAR	Managed Aquifer Recharge
MMISF Act 2005	Maharashtra Management of Irrigation Systems by Farmers Act, 2005
MSRLM	Maharashtra State Rural Livelihood Mission
NGO	Non-Government Organisation

Executive summary

In collaboration with Godrej Agrovet.Ltd, Global Agribusiness Action on Equitable Livelihoods (GAA-EL), and Alliance for Water Stewardship (AWS), this study was designed to explore the level of water resources development and management, and prepare the water stewardship plan for the catchment where Godrej Plant is located in Dindori block of Nashik. As the water is the connecting resource for life and livelihoods as well as agriculture and production, water for drinking and domestic needs, surface and groundwater management, crop management and agriculture practices, marketing and livelihoods are the key aspects researched in the study. These issues are studied with the lens of the normative framework of equity, sustainability, and participation. The study followed a multidisciplinary and mixed-method approach, by applying tools and methods from social sciences, hydrology, geology, geo-informatics, and watershed engineering. The detailed survey and assessments done include interviews and focused group discussions with relevant stakeholders (key villagers, government and non-government officials), a physical survey of water bodies, a detailed well inventory of 200 wells, secondary data from government sources, and satellite images for a different period.

Findings of the study show, the delineated catchment in the area of the Godrej Agrovet plant at Ashewadi village, consisting of 9 villages with an area of 6688 ha. is characterized by modern farming practices, and is well-known for grape and tomato cultivation, with different vegetable crops. Irrigation dams, the canal from the Waghad dam in a few downstream villages, percolation tanks, checkdams, and farm ponds are important water sources for irrigation in the catchment villages. Although groundwater resources have limited availability in the catchment village due to basaltic geological formations, the number of wells in study villages is huge, and farmers are using it mainly for water storage as the groundwater yield is very low.

Water scarcity in summer months for drinking as well as irrigation, poor water quality for drinking water, farming practices with heavy use of chemical and fertilizers, frequent incidences of crop losses, a poor marketing system for tomato and vegetable crops found key problems in the many catchment villages. This is also coupled with poor governance by WUAs and demand-side management of water. To address these challenges, we propose adopting and promoting the water stewardship and climate-resilient Agriculture approaches. The water stewardship framework developed by AWS is a globally recognized tool, and the Water Stewardship approach customized for implementing it at the village level has immense potential to improve the level of water governance.

Given the findings in the analysis, key actions for Godrej to consider as a part of its water stewardship plan covers:

- Repair and maintenance of existing water harvesting structures, mainly the repairing and desiltation of percolation tanks, irrigation dams, and checkdams.
- Groundwater resources, which is the important resource in the catchment villages, can be developed in many folds by applying the techniques of Managed Aquifer Recharge and artificial groundwater recharge.
- The measure of demand-side management by improving soil health, water budgeting processes, improving the marketing system for tomato crops,

promoting FPOs, and capacity building of existing WUAs will certainly be a game-changer in the catchment.

- Considering climate change and increasing sudden weather events, a system of agro-advisories and weather predictions to farmers (grapes and vegetable cultivators) needs to be set for making available crop advisors to farmers based on local weather prediction to reduce the crop losses.
- At institutional and awareness building, strengthening and capacity building of Sanitation and Water supply Committees formed under each Grampanchyat, already formed Water Users Associations, and Women SHGs is required.
- Although the Godrej Agrovet plant is not facing a major water deficit, considering the projected water requirements, the measures for reducing the rate of evaporation from farmpond in the plant will be a very useful and cost-effective solution.

There are certainly challenges in promoting these practices, as these villages are close to cities, farmers mainly settled at farms, and they have very individualistic perspectives regarding the water resources. Most of the villages are receiving water from exogenous sources (from irrigation dams), farmers showed less interest in strengthening local water sources, and mainly developing and managing the groundwater resource. However, we believe that strategies of behavioral change communication strategies, engagement of governing agencies, strategies of capacity building, and enabling farmers for sustainable incomes will certainly enhance the chances of villagers adopting the expected practices.

As the Godrej Agrovet.Ltd is an important stakeholder in the catchment, their role in the design and implementation of these solution measures will be significant, and relevant government and non-government agencies, along with GAA-EL, AWS, and other CSRs may bring the required resources and knowledge to achieve the proposed outcome.

Acknowledgments

This report is an outcome of extensive data collected applying various methods and tools as well as numerous discussions and input sessions of experts and our study partners.

Ashish Bhardwaj from Alliance for Water Stewardship (AWS) is at the center stage in this important study who introduced WOTR to the study partners and brought these partners together. Melanie Levine from Global Agribusiness Action on Equitable Livelihoods (GAA-EL) at the World Business Council for Sustainable Development (WBCSD), Ashish Bhardvaj from AWS, and Ramnath Vaidyanathan from Godrej Agrovet Ltd. gave very useful inputs and immensely contributed in designing and execution of this study. We also received very well-hearted and extended support from Dr. Mohan Kumbhar, Chetan Thorat, and Pavan Phalke from Nashik plant of Godrej Agrovet Ltd., for planning and coordinating the data collection visits. We sincerely thank all of them.

We received very useful and valuable support from Anirudha Mirikar, Kishor Sawande, and Lovelesh Sakat from Sampada Trust, Dindori for planning field work and data collection, we extend our thanks to them. Data collection for the study was possible because of the hard work by our team of field investigators, Govind Sonwane, Gulab Karate, Suresh More, Balasaheb Pande, and drivers Karlos Ohol and Shivaji Pawar. Even during the threat of spreading pandemic (COVID-19), this team provided continuous support, we are grateful to them. During the data collection, many government officials, members of village institutions, and key villagers spent time with us, we are also thankful to all of them.

Dr.Marcella D'Souza, director, WOTR Centre for Resilience studied (W-CReS) and Prakash Keskar, Executive director, Watershed Organisation Trust (WOTR) provided constant guidance and inputs in shaping this study and the study activities. We sincerely thank both of them.

Last but not least, we acknowledge Godrej Agrovet Ltd., Global Agribusiness Action on Equitable Livelihoods (GAA-EL) at the World Business Council for Sustainable Development (WBCSD), and Alliance for Water Stewardship (AWS) for providing the financial support and being the knowledge partners for this study.

Study Team,
W-CReS and WOTR

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Chapter 1. The Context: The biophysical, hydrogeological, and socio-economic characteristics of the catchment

1.1 The Rationale and Objectives of the Study

This section set the context for the report where we discuss the context in which this study is conceptualized with its objectives, component, and outputs planned.

1.1.1 Background and objectives of the study

Water is a connecting resource to different sectors and therefore it needs to be seen from systems and a broader ecosystem perspective. Water is an important connector between agriculture, livelihoods, and biodiversity as well as ecosystem sustainability. This also constitutes an important source for prosperity through industries and water use for commercial uses. Surface water systems (streams, rivulets, and rivers, canals, tanks, and water bodies) play important role in meeting the different water needs (domestic, agriculture, and industries). Along with this, groundwater also plays a vital role in both hydrologic and human systems and is seen as an important buffer/stock in aquifers to deal with changing monsoon patterns and increasing erratic rainfall. Although in regions of assured and good rainfall (As Nashik has around 900 mm and Dindori block 781 mm annual rainfall) (GSDA, 2021; GoM, 2021), increasing dry spells and drought years are increasing. Along with, the water availability issues, water quality problems also is a vital concern in India, as having nearly 70% of water being contaminated, India is placed at 120th amongst 122 countries in the water quality index, resulting in nearly 200,000 deaths each year in the country (NITI Aayog, 2018). The World Bank predicts if the current trends continue, within 20 years 60% of all aquifers in India will be in critical condition (Briscoe & Malik, 2008).

Agriculture is a vital source of livelihood and income for the rural population. Agriculture in Nashik regions has brought good prosperity to farmers, mainly through horticulture (this is a prosperous grape belt) and vegetables and water-saving practices are also adopted at a high scale. However, the region is facing challenges of losing primary productivity of soil as intensive agriculture and heavy use of chemical fertilizers and crop losses due to sudden weather events, along with poor marketing to vegetable crops.

In water resource management today, along with drying rivers and declining water levels, climate change and global warming are of growing concern and India is one of the largest and most important regions of high overall human vulnerability. The climate change phenomenon is directly related to patterns of monsoon behavior and change in temperature, as global warming is likely to intensify, accelerate or enhance the global hydrological cycle. In many cases, data shows that the hydrological cycle is already being impacted. Therefore, in the rain-dependent drylands of India, in which much of Maharashtra falls, erratic rainfall and drought will result in a drastic fall in agricultural production and acute water scarcity for drinking and livelihood purposes. At the institutional level, villagers have do not find incentives to come forward and take the responsibility for managing the local water resources sustainably. Therefore the rule of capture prevail. Hence, it is necessary to prepare and equip rural communities and farmers with knowledge, skills and means to face these challenges to enhance their resilience capabilities. For achieving this, it is necessary that communities are mobilized and sensitized enough and institutional capabilities to be developed so that they understand and realize the value of water in the overall system and take appropriate actions for its conservation.

To address the above-discussed challenges, government departments, many NGOs, corporates, and CSR initiatives have been taking enough efforts for decades. The overall approach of NGOs, Corporates and CSRs have been mainly considering the village as a unit of operation or cluster of neighbouring few villages in a few cases for planning and managing the developmental interventions, without seeing the much needed broader view of the interconnectedness of water resources, with its technical, scientific, socio-cultural, and policy-practice approach at broader geographical, geological and catchment level, and mobilizing the communities and water users at that level for supply and demand side of water management as well as institutional governance. To promote water stewardship by private companies as well as catchment villages AWS has established a framework of water governance standards to be applied be adopted by companies (AWS, 2020), and even WOTR has developed a model of water stewardship to be adopted by villages and at the scale of aquifers (D'Souza et al., 2019).

Godrej Agrovet Limited has two plants in the Dindori block of Nashik district, 1) Commercial R&D & NGCARD Technical (Agrovet) in Ashewadi-Ramshej village, and 2) Godrej Maxximilk in Jambutake village, and both plants have a distance of approximately 11 km. Under CSR activities, the company is doing development and welfare activities for the last few years in surrounding villages. In plant area 1 of the company, WOTR has completed a study with the support of AWS, GAA-EL, and Godrej with the following objectives.

In the context of the above discussion, the main objective of the assessment is to develop and deliver the water stewardship plan based on the framework of the AWS Standard, which includes

1. Preparing detailed stakeholder mapping in the catchment of the Godrej unit at Nashik

2. Preparing water stewardship plan based on AWS standard 2.0 for the catchment

3. Organizing a stakeholder consultation workshop to share the findings and take feedback on the water stewardship plan to prioritize the actions

The study is carried out in the catchment of plant unit in Ashewadi-Ramshej area, Commercial R&D & NGCARD Technical (Agrovet), and the location map is shown in figure1.

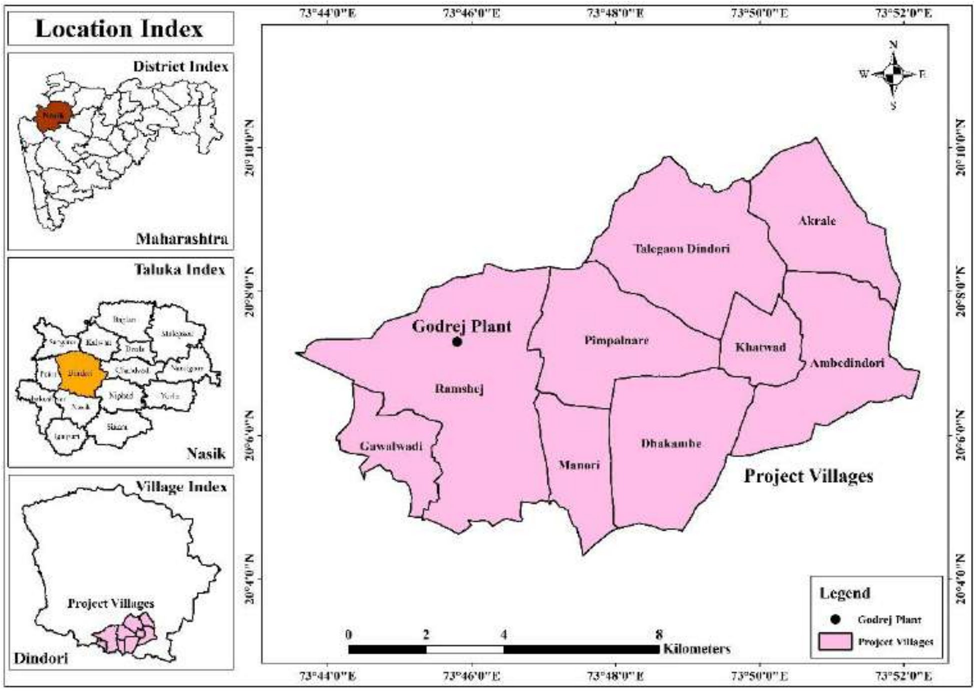

Figure 1 *Location map of the study area*

1.1.2 Components, methodology, and deliverables of the study

Following activities were planned and are completed during the study under different components.

a) **Literature review and building the clarity:** To build the overall clarity of the team on AWS Standard 2.0, the team made a desk review of the standard, and gathered the available literature in terms of data and information in existing reports and studies as well online data available at the different government agencies and department regarding the water sector. This component included the following steps,

   1. Reading and building clarity over AWS standard 2.0. The desk review of existing relevant reports and studies on the proposed study area and AWS training of the WOTR team by AWS.

   2. Catchment delineation based on the secondary data/GIS support and the primary visit made by the WOTR team to the site for ground-truthing and interacting with the Godrej team

b) **Data collection for catchment assessment:** This includes a full assessment of data and capacity at site and catchment level against the core indicators of AWS 2.0. This includes both primary data collection as well as desk review to gather and understand the various water-related data available in various studies and reports available regarding the catchment. There are two outcomes of this component, 1) stakeholder mapping and 2) data of existing soil and water harvesting structures and water-saving practices, groundwater potentials, as well as the scope of problems people are facing regarding quantity and quality of water. The Primary data is collected through field visits, FGDs with villagers, and interviews with key stakeholders. This component followed the below specific steps,

1. Conducted desk analysis of the catchment-based on the secondary data sources, such as RS-GIS, GSDA/CGWB data.

2. GPS survey to geotag various water harvesting structures and major biophysical features of the delineated catchment. Additionally, the dimensions of major water harvesting structures (percolations tanks, irrigation projects, cement check dams, and farm ponds) in the catchment were measured by the physical survey.

3. Conducted the well survey of selected wells in the catchment for delineating the groundwater recharge and discharge zone in the catchment

4. Conducted individual interviews and focused group discussions (FGD) in villages as mentioned below

Interviews: In-depth Interviews with the following respondents have been conducted

1. Mr. Jamadadhe, Taluka Agriculture Officer (TAO)
2. Mr. Vijay Pawar, Block/Mandal Agriculture officer responsible for study-villages
3. Block/Mandal Agriculture officer, Wani
4. Ms. Bangar, Krushi Sahayak, Ashewadi and Manori village
5. Ms. Lokhande, Krishi Sahayak, Dakhambe, and Pimpalnare village
6. Mr. Waghachaure, Gram Sevak, Ashewadi, Manori, and Pimpalnare village
7. Mr. Gangode, Grampanchyat Sarpanch, Dakhambe
8. Mr. R.S. Rakh, Grams Sevak, Dakhambe
9. Ms R.R. Lokhande, Krishi Sahayak, Dakhambe
10. Mr. Kishor Sawande, Project Manager, Sampada Trust, Dindori
11. Mr. Lovelesh Sakat, Field coordinator, Sampada Trust, Dindori
12. Mr. P.K.Jadhav, Ex-Sarpanch and key person, Khatavad
13. Dr. Mohan Kumbhar, Godrej Plant head
14. Someshwar Zadbuke, Godrej Plant official

Focused Group Discussions (FGDs):

1) **Manori**: Incidentally, three was Gram Sabha planned in the village on 7th July, we took this opportunity to present the overall study in the Gramsabha so that more villagers receive the information about the study. Later, with a selected representative group of members, the FGD was conducted.

2) **Ashewadi-Ramshej:** Ashewadi is an important village for this study because of two reasons. The Godrej plant is located in the Ashewadi Grampanchayat and the important tank (minor irrigation project) which supplies water two-three to four villages is also situated in the same village area. This tank is also an important source of drinking water supply in the villages in the catchment. The FGD in the village was conducted where more women were present so that they are also vocal in the FGD and they shared their concerns.

3) **Dakhambe**: Dakhambe village is located downstream of the catchment. In the village, GP sarpanch and deputy sarpanch, Krushi Sahayak, Gramsevak, and a few farmer representatives were present for the FGD. After the FGD, GP sarpanch and other participants arranged a transect walk in the village to show the drinking water supply schemes and other structures.

4) **Pimpalnare**: Pimpalanare is the important village in the cluster as the main waterbody, minor irrigation tank, is located in the village area, almost all farmers are getting irrigation benefits through much-organized water user associations in the village. We have separate FGDs in the village for men and women and thereafter the physical verification of the important water bodies in the village.

5) **Talegaon Dindori**: Talegaon Dindori is the road touch village to the Nashik – Dindori village, we had a mixed FGD with male and female in Gram Panchayat office, and then transect to see the status of major percolation tanks. Industry areas are expanded rapidly in the village for the last 10 years and also some areas of the village and neighboring Akrale village come under the Delhi-Mumbai Industrial Corridor (DMIC project) and the land is already handover to the project.

6) **Ambedindori:** Ambedindori village is at the exit point of the catchment. The FGD was conducted in the Grampanchayat office, Sarpanch and GP members were more concerned about the clean drinking water availability and repair of the percolation tanks in the village.

Photo 1: *Interview with Mandal Krishi Adhikari, Dindori*

Photo 2: *Interview with Taluka Krishi Adhikari, Dindori*

Photo 3: *Interview SampadaTrust (NGO) officials*

Photo 4: *Discussion with people in Manori village*

Photo 5: *FGD with women in Ashewadi village*

Photo 6: *FGD with people in Dakhambe village*

Photo 7: *Discussion with Sarpanch and people in Pimpalnare*

Photo 8: *Discussion with Sarpanch and people in Ambe-Dindori*

1.1.3 Social and Demographic Profile

In the catchment villages, although people of many different castes reside, Maratha and Scheduled Tribe are the dominant caste groups. As per the 2001 census, the population of the identified catchment is 18735, with a total number of households of 3454. As Dindori block has a high number Scheduled Tribe population, this is also reflected in the study villages in the catchment where the population of ST castes is 33%, and most of the population belongs to Mahadev Koli caste. The highest concentration of ST population is in Ramshej-Ashewadi, Ambe-Dindori, and Gavalwadi villages. Scheduled Population is well spread in all villages, except Gavalwadi village as given in table 1.

Table 1: Demographic details of catchment villages

No.	Village Name	Census Code	Total Households	Total Population	Total Male Population	Total Female Population	Total SC Population	Total ST Population
1	Ramshej	550570	447	2496	1277	1219	61	1294
2	Pimpalnare	550571	587	3178	1637	1541	324	688
3	Manori	550572	159	885	491	394	35	228
4	Talegaon Dindori	550660	518	2761	1421	1340	300	871
5	Khatwad	550669	268	1458	760	698	19	384
6	Dhakambe	550670	500	2890	1471	1419	241	705
7	Akrale	550661	346	1688	876	812	263	218
8	Ambedindori	550668	516	2756	1404	1352	227	1209
9	Gawalwadi	550569	113	623	322	301	0	575
Total			**3454**	**18735**	**9659 (52%)**	**9076 (48%)**	**1470 (8%)**	**6172 (33%)**

The settlements are very scattered as many farmers are settled and constructed homes in their farm land. Apart from Pimpalnare, Talegaon Dindori, and Ambe Dindori, in most villages, farmers are settled in farms.

1.1.3 Socio-cultural, and historical features of the region

Nashik district has an ancient, historical, and cultural background. The District has a great mythological background. Lord Rama lived in Panchvati during his *vanvas* (exile period). Agasti Rushi also stayed in Nashik for Tapasya. The origin of the name Nashik is linked with the epic of Ramayana. According to this epic, Laxman cut off the nose of Shurpanaka of Ravana's sister. So this place was called 'Nasik'. The Government of Maharashtra changed it to Nashik. Nashik is also best known for being one of the Hindu pilgrimage sites, that of Kumbh Mela which is held every 12 years (GoM, 2021)

The Godavari River originates from Trimbakeshwar in Nashik. One of the 12 Jyotirlingas is also at Trimbakeshwar. Nashik is also known as Mini Maharashtra because the climate and soil conditions of Surgana, Peth, and Igatpuri resemble Konkan. Niphad, Sinnar, Dindori, Baglan blocks are like Western Maharashtra, and Yeola, Nandgaon, Chandwad blocks are like Vidarbha Region. Nashik, Malegaon, Manmad, Igatpuri are some of the big cities situated in the Nashik District, Thus within a district, there is huge diversity in terms of agro-climatic and biophysical features.

Peninsular India's largest river Godavari originates in the district in the Trimbakeshwar Range and continues its eastwards through the district. The Satmala-Chandwad Range forms a watershed, such that, the rivers emerging to its south drain into the Godavari. These include the Kadva and Darna both of which are tributaries of the Godavari. To the north of the Satmala-Chandwad Range, the Girna River and its tributary, the Mosam, flow eastward through fertile valleys into the Tapti River (CGWB, 2014).

The western part of the district viz. Peth, Kalwan, Dindori, Igatpuri, Trimbakeshwar, and Surgana tahsils are hilly. Scheduled tribe population in the majority are residing in the hilly areas and their main occupation is cultivation and collection of forest produce. The Nashik is called and known as the "Wine Capital of India" as half of India's vineyards and wineries are located in Nashik (GoM, 2021).

1.2 The Biophysical Characteristics of the Catchment

The Nashik district is broadly divided into three major geographical regions. The downghat Konkan tract, the Girna basin, and the Godavari basin. The downghat Konkan tract is a highly dissected plateau lying to the west of Sahyadri edge of the Deccan plateau. It is a series of valleys and resulting from dissection by streams and running in very deep beds. The Girna basin is stretched east of Sahyadri hill ranges and north of Sawatamal hills. The river Girna is a tributary of Tapi River having a gentle to a medium slope. The Godavari river basin is stretched east of Sahyadri hill ranges and south of Sawatamal hills.

The identified catchment is located in the Upper Godavari basin and is in the southern part of Dindori taluka of Nashik district, Maharashtra. The catchment covers 9 villages from the upper catchment to the outlet point as shown in figure 2. The Godrej plant is situated in the northeast part of the catchment and falling in the upper catchment. This catchment is falling in the upper catchment of the Godavari river basin. The geographical extent of the catchment ranges from Longitude 73.7597 - 73.8396 and Latitude 20.1667 - 20.0797. The total geographical area of delineated catchments is 6688 hectares, and the elevation in the catchment ranges between 596 – 1079 meters. To assess the biophysical characteristics of catchment have used freely available SRTM 30m digital elevation model from USGS Earth Explorer (https://earthexplorer.usgs.gov/), Sentinel-2 satellite images of Kharif, Rabi, and summer seasons respectively, rainfall data is analyzed from the nearest available rain gauge station of Government of Maharashtra (GoM, 2021a). Soil data is used from NBSS&LUP, which is available at 1:250 K scale.

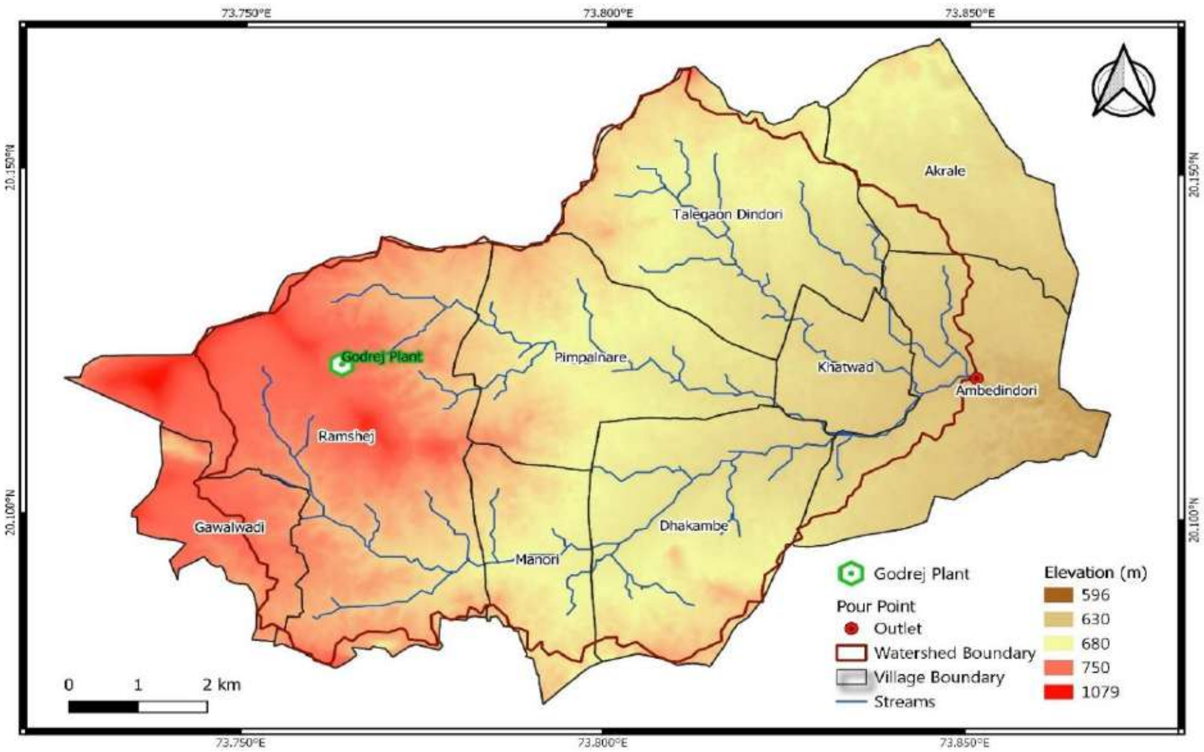

Figure 2 Catchment area and Drainage map

Table 2: The geographical details of the catchment villages

No.	Village Name	Total Geographical Area (in Ha.)	Nature of Geographical area in the catchment
1	Ramshej	2571	Full
2	Pimpalnare	1028.16	Full
3	Manori	511.52	Full
4	Talegaon Dindori	1337	Full
5	Khatwad	366.71	Full
6	Dhakambe	1100	Full
7	Akrale	983	Partial
8	Ambedindori	1087	Partial
9	Gawalwadi	419	Partial
Total		**9403.39**	

Although the total area of these 9 villages is 9403 ha, only the first 6 villages shown in the table fully fall under the delineated watershed, and the partial village area of the rest of 3 villages falls in the watershed. Therefore, although the total area in these 9 villages is 9403, the total area of the delineated catchment is 6688 ha (table 2).

Photo 9: *Upper part of the catchment showing Godrej Plant and Pimpalnare dam*

Rainfall is one of the prime climatic factors which influences the agro-economy and the productivity of crops is majorly dependent upon the quantum, intensity, and distribution of rainfall in space and time. The distribution of rainfall across the Nashik district is variable and is strongly influenced by Physiography. The western parts experience heavy rainfall up to 3000 mm. The eastern and south-eastern tahsils have an average of 550 mm rainfall while the central portion of the district has 700 mm average rainfall

The annual average precipitation of the Dindori block in which the catchment fall is 781 mm. During the last 8 years, in Dindori, where the study catchment fall as shown in table 3 rainfall ranges from 744 mm to 1819.9 in 2017, even number of rainy days ranges between 53 and 74 (GoM, 2021a). The summer period is recorded with a maximum temperature of 42.5°C whereas winter registered its minimum temperature of 5.0°C with the relative humidity range of 43% to 62% (CGWB, 2014).

Table 3: Annual rainfall for Dindori block in Nashik

Year	Total Rain for Year		
	Normal Rain	Actual Rain	Rainy Days
2013	781.3	961.7	69
2014	781.3	712.8	61
2015	781.3	744.3	53
2016	781.3	1131.4	57
2017	781.3	1819.9	74
2018	781.3	926.1	64
2019	781.3	1371.2	70
2020	781.3	925.8	74

The point to highlight in the rainfall data is that during 2016 the rainfall was around 25% more than the average rainfall and in 2017 the actual rainfall was more than double of the average rainfall (figure 3), however, the number of rainy days remained the same, generating more flooded runoff. Such events of erratic monsoon are reported to be increased with climate change projections in near future and we will discuss in the coming sections on dealing with this changing monsoon on climate-proofing strategies required for the watershed.

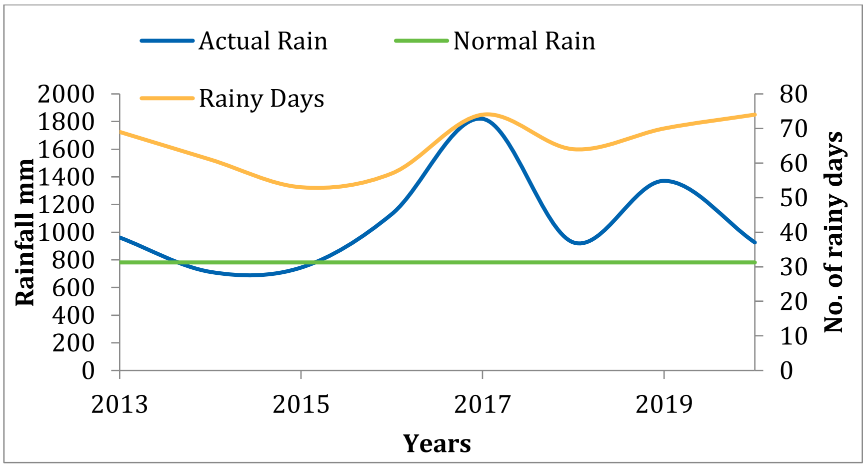

Figure 3: Rainfall distribution in Dindori Block, Nashik

1.2.1 Soil and Land Characteristics

More than half of the catchment area is having loamy soils while the remaining part is under clayey soils as shown in figure 4. Mainly the upper catchment areas are falling under loamy soils while clayey soil is present in the lower and middle catchment, with is a small area in In Akrale and Ambe Dindori village with loamy soil.

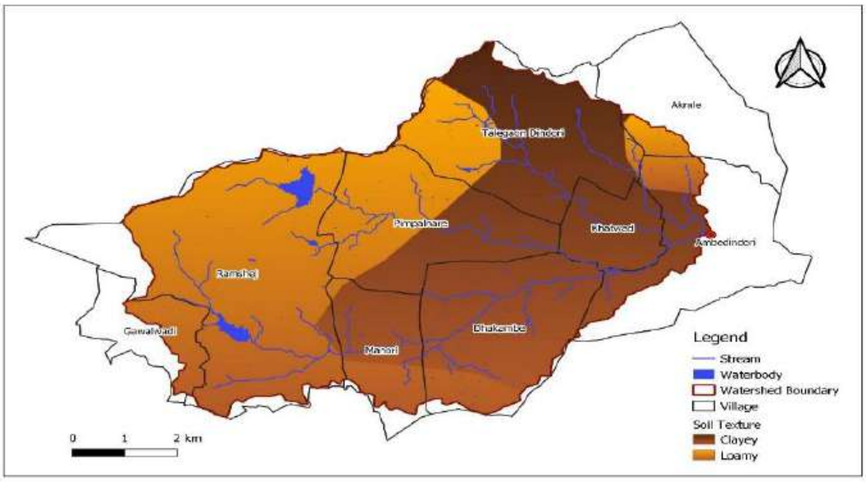

Figure 4: Soil map of the catchment (Data Source: NBSS & LUP)

The majority of the geographical area is under agricultural land (cropland + current fallow land) in the catchment and some parts are covered by vegetation and wastelands. Additionally, few industries are also present in the catchment.

In most areas in the catchment, the soil depth is not very deep, approximately 2 feet, even

Banganga river bed at many places is rocky. The geological formation in many wells also substantiates the very less soil depth as many wells don't have the initial social layer of more than 2 feet. Low soil depth and hard rock below are also reported as the major cause of heavy runoff of rainfall from the catchment as there is very poor percolation potential in the catchment area.

1.2.2 Land Use and Land Cover (LULC) Characteristics

Based on the initial field observation and existing land distribution, the study regions were categorized into six land classes as shown in table 4.

Table 4: LULC classes are defined based on supervised classification

Sr. No	Class Name	Description
1	Cropland	Crop fields in Kharif/Rabi/summer season
2	Vegetation	Trees forming open to closed canopies, less than 10 %, 30–70 %, and more than 70 % respectively, Scrub land/forest.
3	Wasteland	Land surface devoid of vegetation, Barren/ rocky land, and open scrubs
4	Fallow land	The land using for farming but is left with no crops
5	Settlements	Residential, commercial, roads, mixed urban
6	Waterbody	River, open water, lakes, ponds, and reservoirs
7	Industrial area	Industrial units or plants

We have used European Space Agency (ESA)'s Sentinel-2 satellite images with a spatial resolution of 10 meters (i.e., objects >10 m can be reliably mapped) for mapping of land use land cover (LULC) classes in the catchment area. Sentinel-2 satellite imagery contains 13 bands out of them 8 have been used in this study, these images are obtained from the Earth explorer online portal for three different seasons i.e. Kharif, Rabi, and summer for the year 2020-21. Satellite images of October 2020 (Kharif season), January 2021 (Rabi season), and April 2021 (summer season) have been used to map seasonal LULC features in catchment areas.

Three seasons LULC maps i.e. Kharif (monsoon), Rabi (winter), and summer of the year 2020-21 representing the spatial disposition of various land use land cover features in the catchment are prepared. This information is further used to calculate the area under each class in the catchment. Seasonal satellite images used for LULC mapping are shown in figures 5, and 8 for Kharif, Rabi season, and similarly, the seasonal LULC maps of 2020-21 are shown in figures 6, 9, and 11 for the catchment.

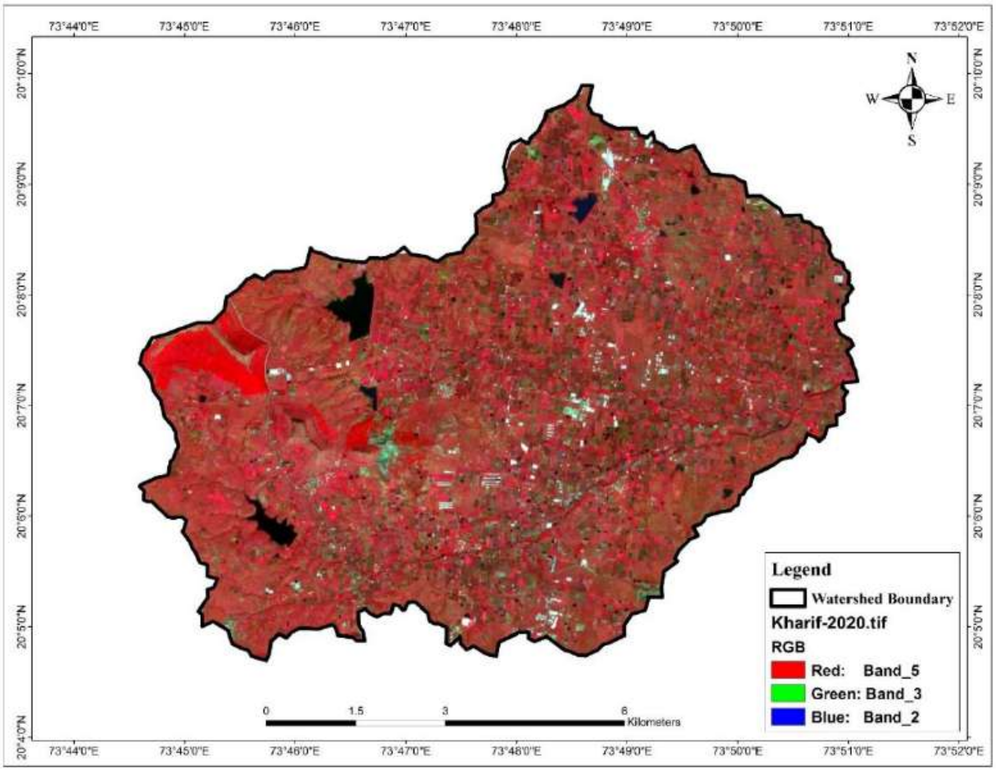

Figure 5: *Satellite image of Catchment- Kharif 2020-21*

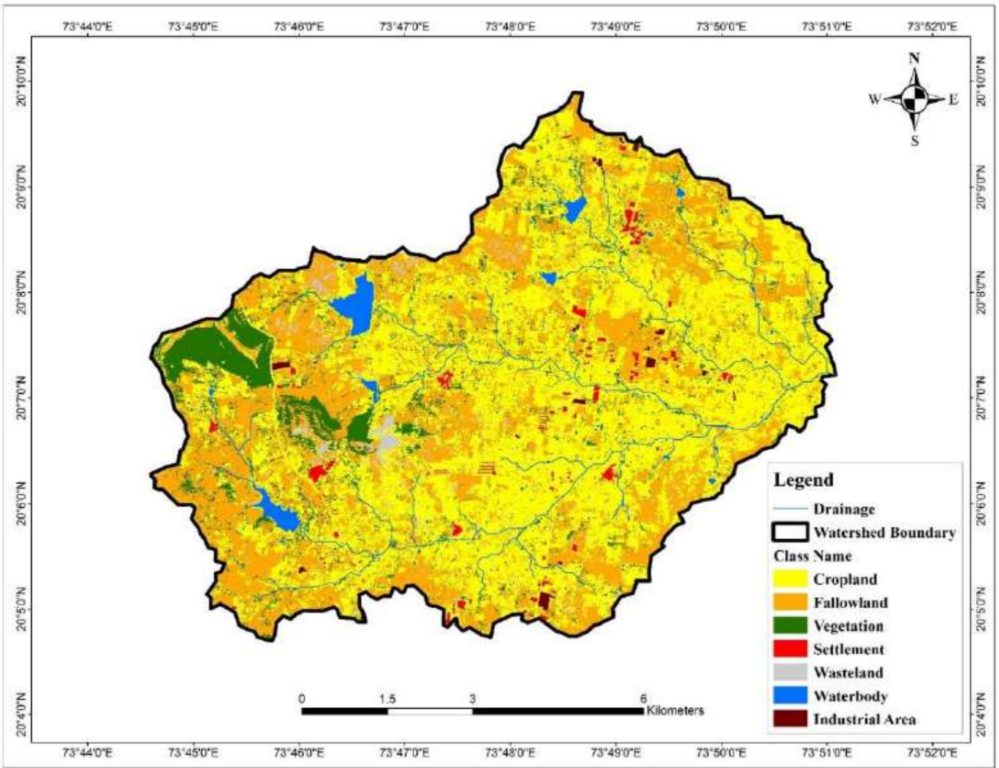

Figure 6: *LULC map of Catchment- Kharif 2020-21*

The LULC spatial analysis revealed that during the Kharif season (2020-21), the area under crops is 3445 hectares (51.3 %) followed by the fallow land- 2291 hectares (34.1 %). Vegetation land is also significant which is accounting for 8.2% (553 ha.) of TGA catchment. Wastelands are occupying 203 hectares of land in catchment while the area under surface water bodies is 110 hectares. Around 90 hectares of land is under settlements and 23 hectares is under industrial sites (figure 6, 7).

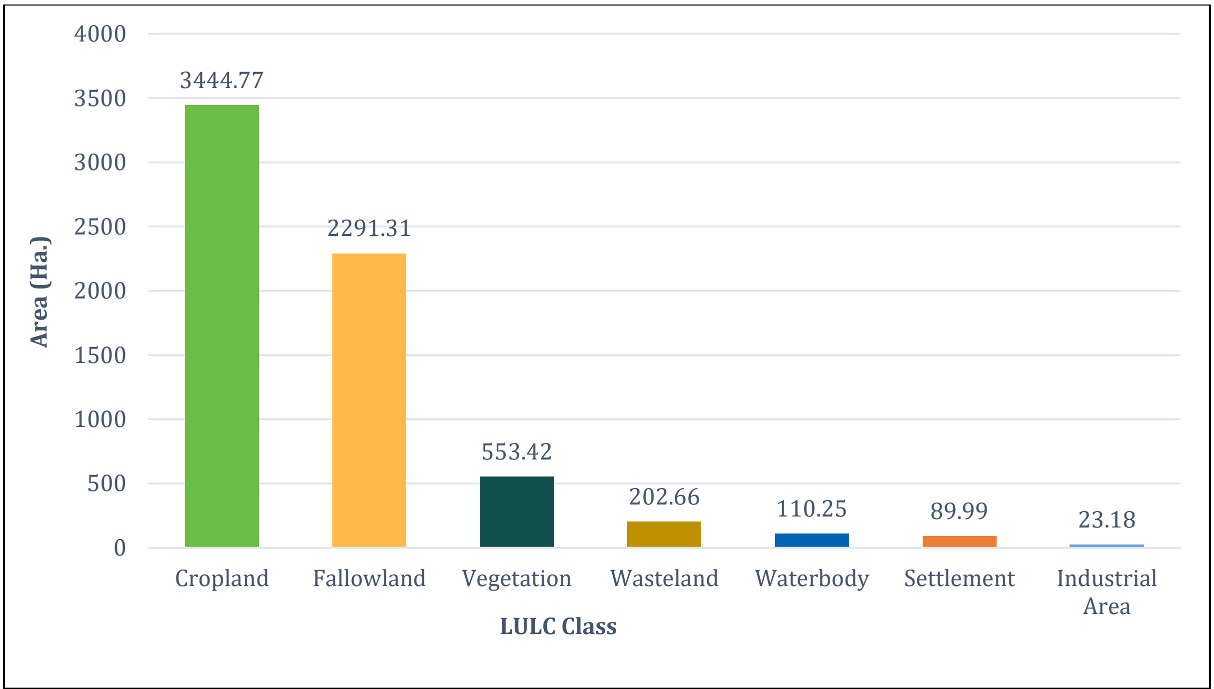

Figure 7: *Land use land cover area statistics of the catchment for Kharif 2020-21*

The results of LULC mapping show that during the Rabi season (2020-21), the area under crops is 2460 hectares (36.6 %) which is less than that of the Kharif season. The fallow land has increased in Rabi season as compared to Kharif; amounting to 3559 hectares (53 %). Vegetation land is also reduced to 309 hectares (4.6 %) which was 8.2% (553 ha.) during the Kharif season. Wastelands are occupying 203 hectares of land in catchment while the area under surface water bodies is 72 hectares. Around 90 hectares of land is under settlements and 23 hectares is under industrial sites (figure 9, 10).

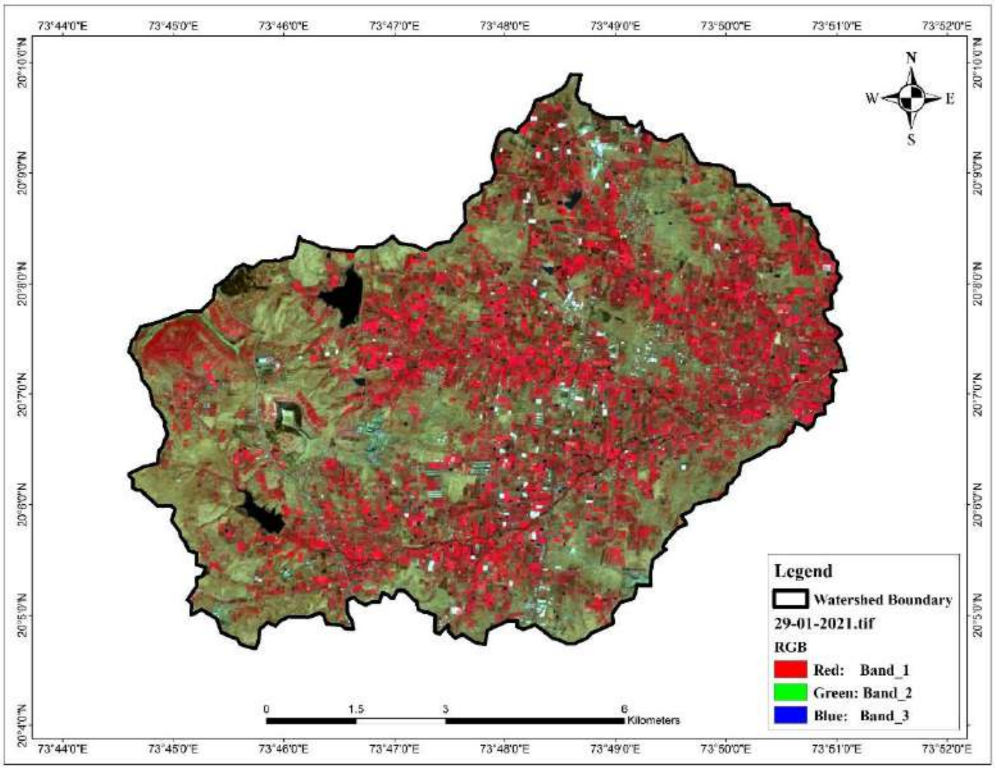

Figure 8: *Satellite image of Catchment- Rabi 2020-21*

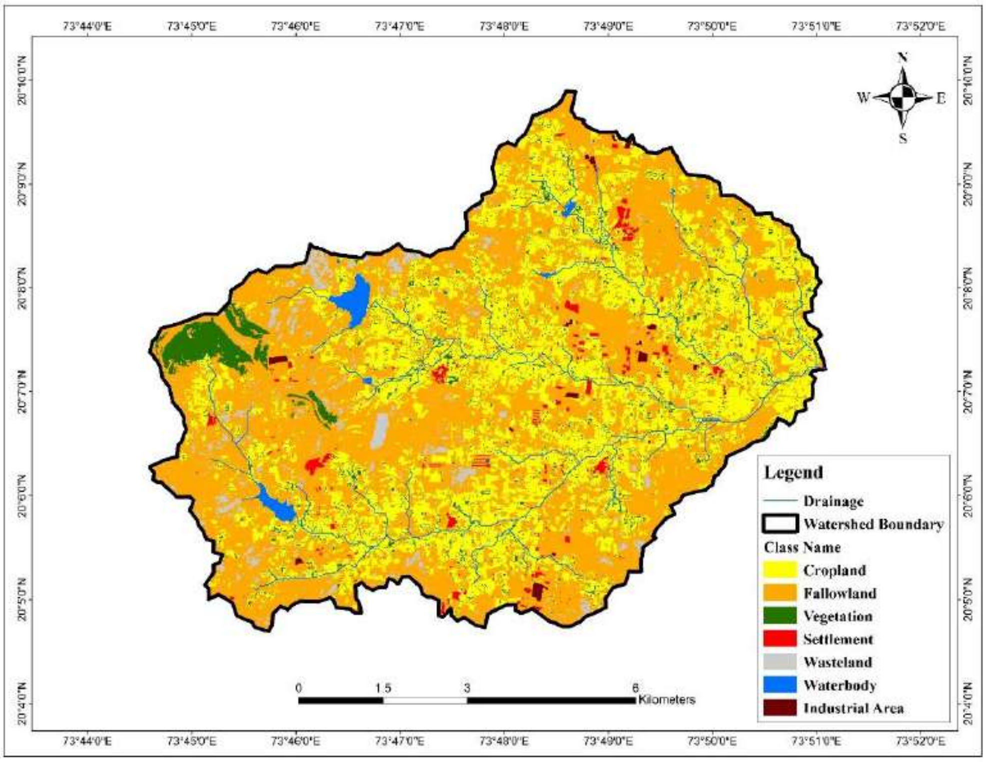

Figure 9: LULC map of Catchment- Rabi 2020-21

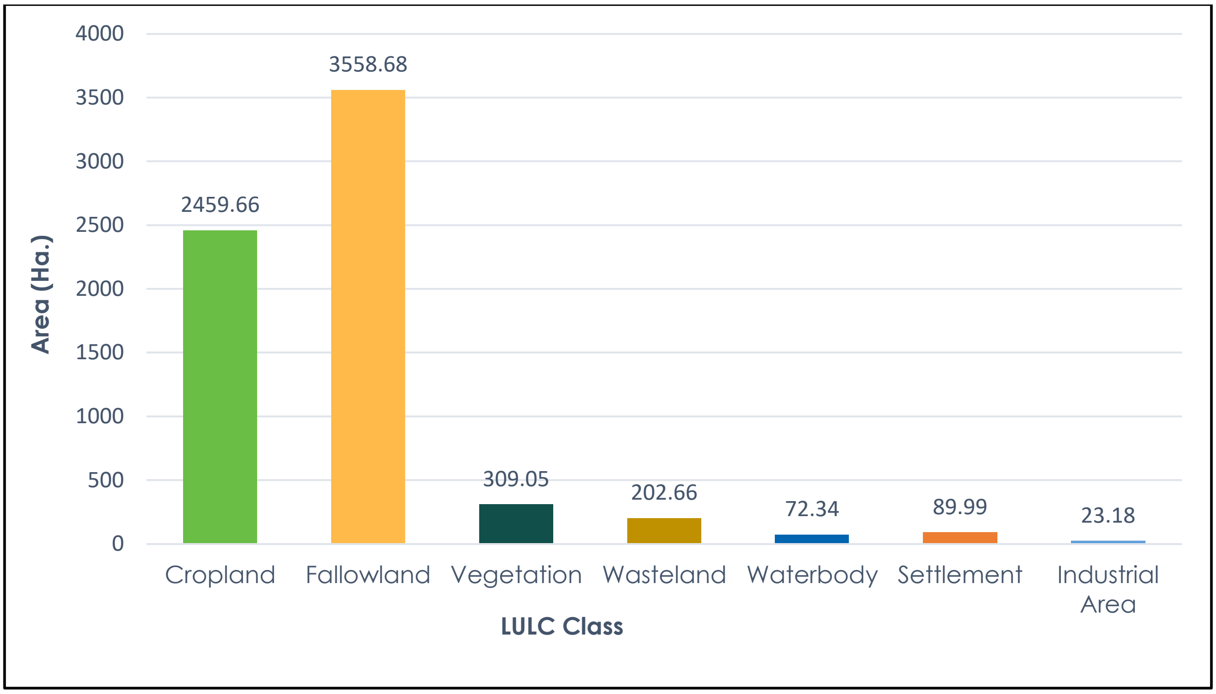

Figure 10: *Land use land cover area statistics of the catchment for Rabi 2020-21*

The findings of LULC mapping show that during the summer season (2020-21), the cropped area is significantly reduced (almost half) as compared to the Kharif season; the area under cropland is 1609 hectares (24 %). The fallow land has drastically increased in the summer season as compared to Kharif and Rabi seasons; amounting to 4450 hectares (66 %). The farmers take more cash crops in catchment areas during the Rabi season and subsequently the water availability gets reduced in the summer season which has resulted in this increase in fallow land and decrease in cropland. Vegetation land is also reduced to 284 hectares (4.2 %) which was 8.2% (553 ha.) during the Kharif season. Wastelands are occupying 203 hectares of land in catchment while the area under surface water bodies is further reduced to 55.7 from 110 hectares in Kharif. Around 90 hectares of land is under settlements and 23 hectares is under industrial sites (figure 12, 13).

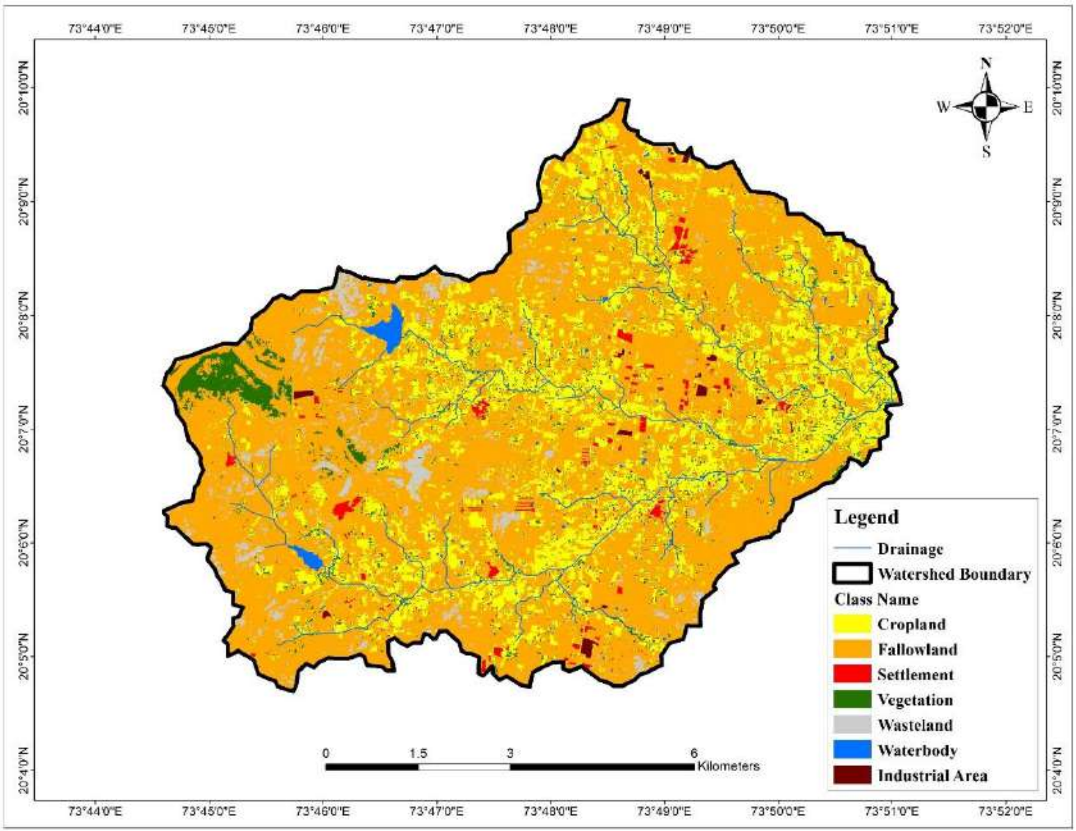

Figure 11: *LULC map of Catchment- Summer 2020-21*

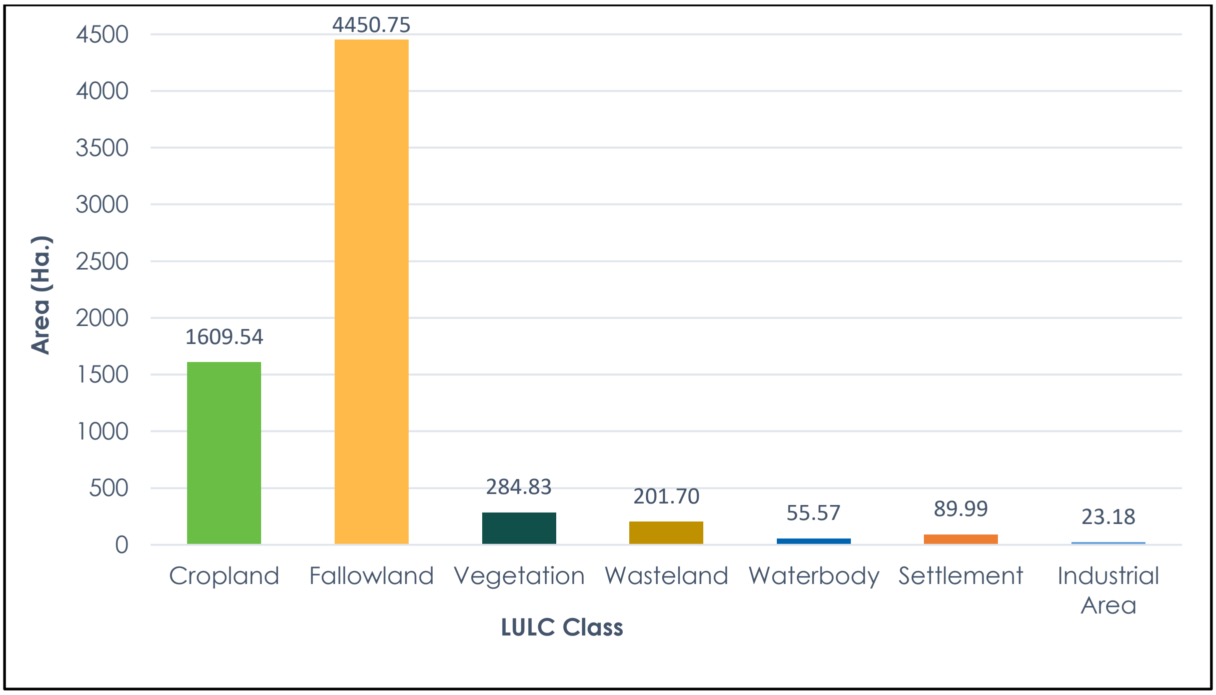

Figure 12: *Land use land cover area statistics of the catchment for summer 2020-21*

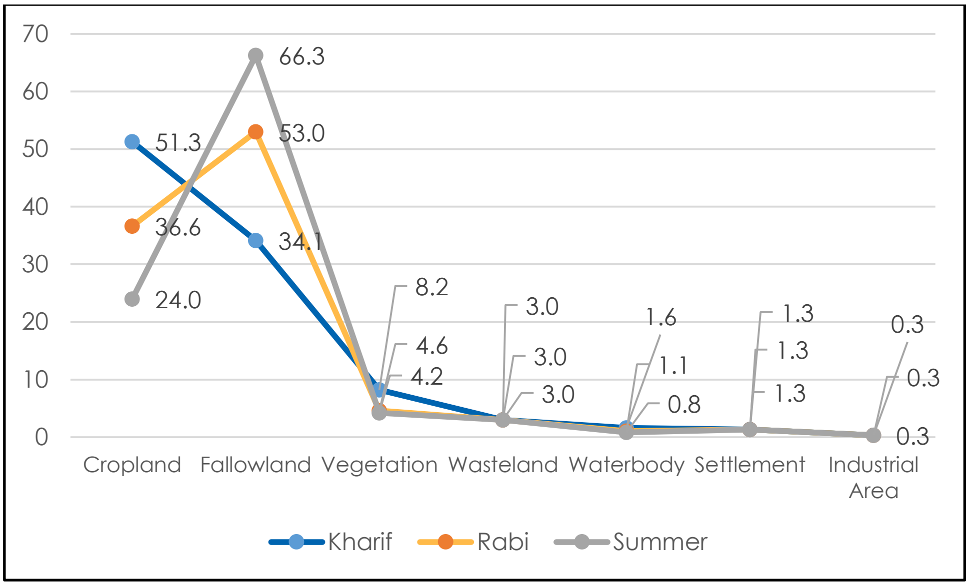

Figure 13: *Land use land cover area statistics of the catchment for three-seasons*

Overall, the season-wise LULC characteristics of the catchment are summarized in figure 13, which shows the % area of various LULC categories with respect to TGA. It is indicating that cropped area is highest in Kharif season and gets reduced in Rabi and summer seasons as water availability reduces. The fallow land also exhibits the same trend i.e. after the Kharif season the area under fallow land keeps increasing. The surface water spread area or waterbodies (irrigation dams/reservoirs/etc.) was highest in Kharif and reduced by 50% in the summer season. The vegetation cover in the catchment was also highest in the Kharif season, and during Rabi and summer seasons this remained almost similar.

1.2.3 Crops, Agriculture and Water use Practices

Farming in the catchment is very progressive and modern, and most farmers are also better off. Although the Grapes is the main perennial crop in the catchment, the tomato is the second largest crop being cultivated by farmers, and even two central villages in the catchment Pimpalnare and Talegaon Dindori have almost 75% of the cultivable area under the tomato crop, even all rest of villages have a substantial area under tomato crop. Mainly tomatoes get cultivated during the Rabi season in the majority of areas, however, they get cultivated throughout the season in the catchment. Different vegetables, mainly various types of beans, cabbage, cauliflower, potato, cucumber, and flowers (manly marigold and aster) get cultivated in Kharif and Rabi. The potato crop is being cultivated in Dakhambe in an extensive area. Rice (in Talegaon Dindori and Ashewadi) and sugarcane (for fodder purpose) is getting cultivated on the very insignificant area in the catchment (Table 5). In short, the dominant crops in catchments the farmers cultivate in the areas are tomatoes and grapes.

Table 5: Details crops and water use practices in the catchment

Season	Major Crops	Use of micro-irrigation	Use of chemical & fertilizers	Use of plastic mulching paper
Kharif	Tomato, Soybean Groundnut, Maize, Vegetables-French Beans, Cauliflower, Cabbage, Brinjals, Red gram	90% crop area under Micro-irrigation (drips and sprinklers)	Heavy use of both, chemicals and fertilizers	Extensive use of plastic paper for Tomato and vegetables
Rabi	Wheat, Chickpea, Onion, Tomato, Potato, Flowers, Maize Vegetables-French Beans Cabbage, Cucumber, Brinjals	90% crop area under Micro-irrigation (drips and sprinklers)	The moderate use of chemicals and heavy use of fertilizers	Extensive use of plastic paper for Tomato, flowers, and vegetables
Summer	Vegetables, Tomato, Onion, Groundnut, Flowers	90% crop area under Micro-irrigation (drips and sprinklers)	Heavy use of both, chemicals and fertilizers	Extensive use of plastic paper for Tomato and vegetables
Horticulture/perennial	Grapes, Guava, Papaya, Lemon	90% crop area under Micro-irrigation (drips and sprinklers)	Heavy use of chemicals and moderate use of fertilizers	No use of plastic mulching paper

Photo 10: *Grape plot in the Pimpalnare*

Photo 11: *cabbage plot in the Manori village* ***Photo 12:*** *Tomato plot in the Dakhamabe village*

Photo 13: *Tomato plot in the Ambe Dindori village* ***Photo 14:*** *Beans plot in the Ashewadi village*

Photo 15: *Cucumber plot in the Ambe Dindori village* ***Photo 16:*** *Flower plot in the Ambe Dindori village*

Micro-irrigation is widely adopted for all irrigated crops and vegetables, and hardly one can see the flood irrigation practice in the catchment. Most farmers understand the economic value of water as they invest heavily for water availability in constricting farm ponds and paying charges for water through water users associations as they get water through WUA's of being members of it.

What is alarming in agriculture practices in the catchment is the extensive use of chemicals and fertilizers. Grapes, tomatoes, and different vegetables throughout the year get cultivated with a high level of inputs of fertilizers and chemicals by spraying very frequently. The crop practices and cultivation is very intensive and therefore hardly the land and soil get free time (fallowing period) for its natural processes to build soil fertility or break the pest and disease cycle. According to the farmers because of intensive agriculture, without crop rotation, and a heavy dose of chemicals and fertilizers, the soil quality is deteriorating and primary productivity of the soil is lowered, therefore they use more high inputs. However, it is also observed that few farmers (Ashewadi, Pimpalnare, and Khatwad) purchase organic manure (cow dung) from nearby cities outside the catchment for agriculture purposes and the cost per track-load is reported as Rs. 20000.

The practices of plastic use in agriculture that is popularly known as 'Plasti-culture' is rapidly increased since the last 10 years in the catchment. Plastic is being used mainly for three purposes in farming, i) mulching paper for cultivating vegetables and mainly for tomatoes, ii) lining of farm ponds, and iii) used for drip irrigation. When this plasticulture is used wisely and in a limited manner, certainly it is beneficiary, but its excessive use, as shown in the below pics in the catchment has certainly the threat for environment and soil, and this is well researched in WOTR's earlier studies (Srinidhi A, & Nazareth D, 2018)

Photo 17: Plastic application for tomato and farm pond in Ashewadi

Photo 18: Plastic mulching paper application in Manori

Crop loss and crop failure due to sudden weather events are some of the key concerns shared by farmers and since the last few years, the frequency of such events has been increased. Farmers reported that mainly events of hail storms, hot and cold waves, cloud bursting, cyclones have increased, and these are affecting mainly grape and other vegetable crops. At present, for meeting the crop loss farmers mainly depend on the scheme of crop insurance they have applied for, however many times they receive a very nominal amount as crop insurance. The farmers shared that few of them are receiving the agro-advisories and weather predictions through mobile SMS from KISAAN and other apps, however as these adversaries are generic for blocks and districts, they are not very useful and locale-specific to local conditions.

1.3 Water sources, Institutions, and Management

According to the Taluka Agriculture Officer (TAO) of Dindori, despite having several dams in the catchment, the non-existence of a proper network of canals and minors (distributaries) and the poor quality at different places have increased the dependency of farmers on the groundwater resource. In Khatvad, Dindori, Ambe Dindori villages, many large landowners have their own (in group and private) pipelines from the dams however small and marginal farmers suffer from water shortage. For example, in Ashewadi farmers reported difficulties and water shortage in cultivating crops during summer and, a similar situation is reported in Manori and Dakhambe villages where irrigating crops during Rabi and summer has challenges as dug wells get dried. Therefore developing the local water sources, through soil water conservation measures (catchment development plan), is very essential. He also concluded that local farmers will certainly take interest and offer participation as they are feeling the need to strengthen local water resources, rather than always exporting water outside the catchment, and drinking water availability throughout the village may be the common triggering point to bring all of them together.

Regarding water resource management, there are two important institutions in almost every village. The Water Supply and Sanitation Committee formed under Grampanchayat is formally formed in each village, however, it has been observed that this committee is nominal and not meeting and functioning. Even, in a few villages for example Talegaon Dindori and Pimpalnare, the tenure of Grampanchayats has been over since last year, but elections have been postponed due to COVID-19 lockdown guidelines. Therefore these Grampanchayat are functioning under the nominated government officer as Sarpanch, this mechanism is also discouraging for planning and meetings of committees formed under Grampanchayat.

The other important institution in the villages is the Water Users Associations (WUAs) formed in these villages under MMISF Act 2005. WUAs played a crucial role in making water available to farmers, managing the maintenance of these schemes, and thus resulting in the enhancing agriculture income of farmers. In general, WUA is a formal group of farmers who get registered and get benefits of irrigation water from irrigation projects. The group member is charged based on the area under irrigations and fees get collected by an elected body of the group to be paid to the irrigation department. Even, the Act also has a provision that if WUAs are capable, the department can transfer the management of the irrigation project to the WUAs. There is a wide range of WUAs formed in the catchment villages and many farmers are benefiting from these institutions, however, all WUAs are not functioning at an equal level.

Table 6: Details of WUAs in the catchment villages

No.	Village name	Name of Water User Association	Total Members	water source	Distance from Source in Km
1	Ashewadi	Pawan-putra Hanuman Pani-Vapar sanstha	115	Ashewadi dam	
2	Pimpalnare	Shri Ram Pani-Vapar Sanstha	350	Pimpalnare Dam	0.5
3	Manori	No Water User's Association	80	Ashewadi river (private)	2.5
5	Ambe Dindori	Lakshmi Mata Pani-Vapar Sanstha	400	Canal from Waghad dam	2.5
6	Ambe Dindori	Baneshwar Pani-Vapar Sanstha	500	Canal from Waghad dam	2.5
7	Talegaon Dindori	Biroba Pan-Vapar Sanstha	100	Canal from Waghad dam	4
8	Khatwad	Shree Ram Pani-Vapar sanstha	26	Canal from Waghad dam	0
9	Khatwad	Bajrang Pani-Vapar sanstha	125	Canal from Waghad dam	0
10	Khatwad	Saptashrungi Pani-Vapar sanstha	25	Canal from Waghad dam	0
11	Dhakambe	Banganga Pani-Vapar sanstha	175	Ashewadi river	5
12	Dhakambe	Private lifts	100	Canal from Waghad dam	2.5

The WUA in Pimpalnare village, Shri Ram Pani-Vapar Sanstha (WUA), is the ideal one in the catchment this has 350 farmers as members (table 6). The WUA is regularly meeting, water charges are getting collected regularly and the person is deputed by the WUA to regulate the pumps for different subgroups of farmers in the village. The Pimpalnare minor irrigation dam, which is the largest water body in the catchment, is handover to this WUA, and they have made the rules not to allow water outside the village area, and not even to the outside person from the village who purchase the land in the village, thus the functioning of Shri Ram Pani-Vapar Sanstha in Pimpalnare is the ideal example or model for other WUAs in the catchment for surface water management (water from canals and tanks). The rest WUAs in the catchment villages are also active at a different level and their capacity building and follow-up will certainly be useful for improving the efficiency and effectiveness.

Photo 19: *Office of Water Users Association in Pimpalnare village*

Photo 20: Pimpalnare dam, the largest dam in the catchment

Photo 21: *Minor, Water distributary from the canal in Khatwad*

1.4 Hydro-geological Characteristics

This section presents the details of surface hydrology, geology, and groundwater resources, thus the section gives the complete picture of the water resources in the catchment.

1.4.1 Surface water bodies, drainage system/rivers in the catchment

There are 3 major irrigation dams present in the catchment each one in Pimpalnare, Aashewadi, and Talegaon Dindori villages. The dam in Pimpalnare is the minor irrigation dam and the largest water body in the catchment. The farmers in catchment use these dams extensively especially in the Rabi season for irrigation. Apart from these major dams, there are 18 small percolation tanks or earthen bunds in the catchment, mainly falling in Ashewadi, Talegaon Dindori, and Ambe-Dindori villages. One canal is also flowing in the lower part of catchments shown in figure 14. Banganga River is flowing in the catchment and rises a little to the northwest of Ramshej hill, and continues flowing in a generally easterly course. Banganga is a small tributary of Godavari River and after passing Sukene it joins the Godavari. In the catchment area, it passes through five villages (Figure 14).

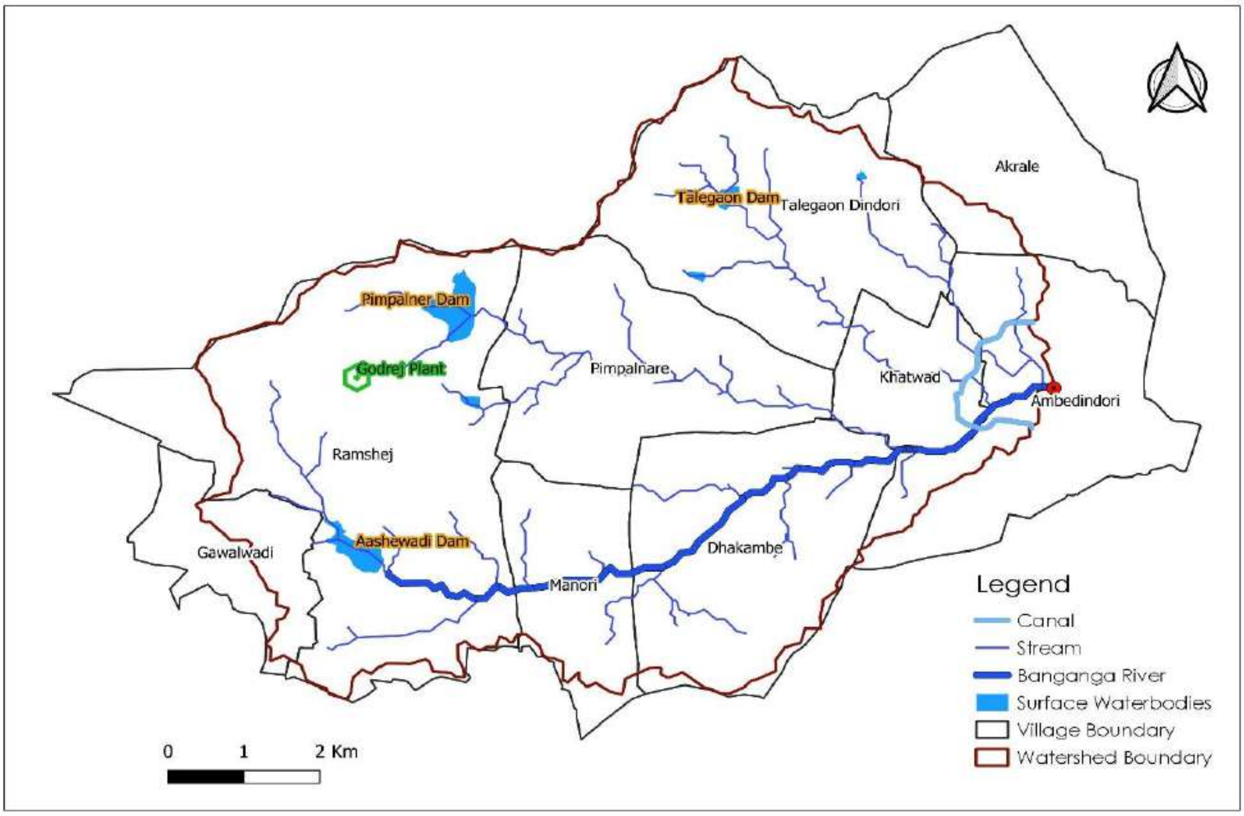

Figure 14: *River, canals, and drainage map of the catchment*

1.4.2 Geological Formation

The Nashik district is monotonously covered by the basaltic lava flows, called the 'Deccan trap'. These rocks have been considered to be a result of fissure type of lava eruption during the Cretaceous – Eocene period. The age of the Deccan Trap is 45 million years.

They have the tendency to form flat-topped hills giving rise to a plateau, comprising of lava flows each ranging from a few meters to 30 meters in thickness.

To study the geo-hydrologic aspects and rock structures in the identified catchment in the Dindori block, we did an extensive assessment of the area through the detailed well survey (well inventory) of 200 wells scattered in the catchment. The main purpose of this investigation is to identify the recharge and discharge area and the potential of aquifers to store the groundwater. The selected wells are geotagged and monitored for water level fluctuation in the catchment as the well geological formation is studied of these wells. Figure 15 presents the spatial representation of wells studied in the catchment for the study.

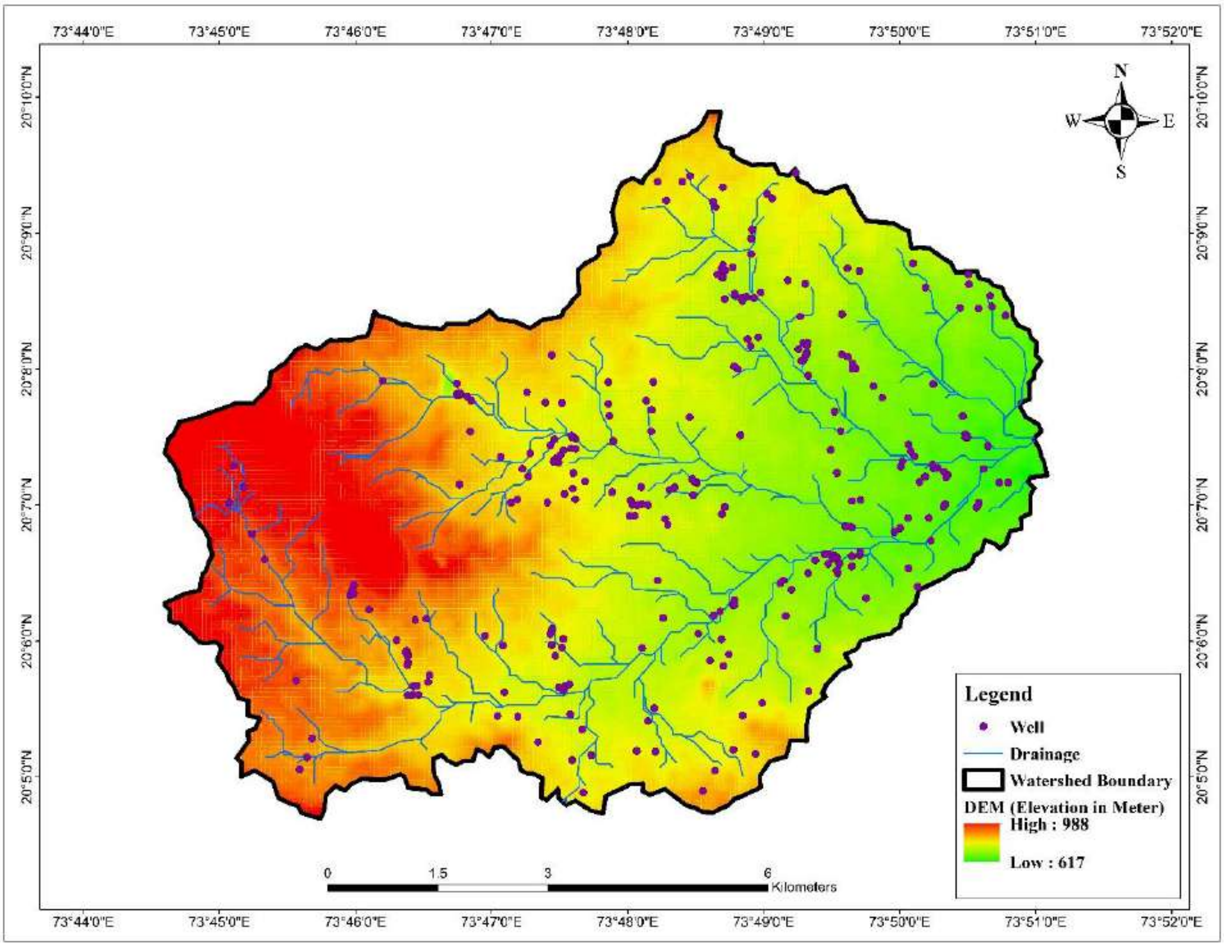

Figure 15: *Catchment of the study area with the distribution of observation well*

The study catchment is also dominated by basaltic flows, which are horizontal and give rise to tabletop-looking topography, which is also known as a plateau and these individual flows are separated with the marker bed known as red bole or intertrappean. The Basaltic flow is majorly divided into three parts; i.e., The top layer is attributed as the upper amygdule zone, followed by the middle vesicular zone, and finally goes down to the bottom massive lava flow. However, it is not certain to get all sequential layers at every location because of the nature of eruption and distribution of lava in space and time. Basalts are extrusive igneous rock, composed of Plagioclase feldspar, Pyroxene, olivine, hornblende, biotite, and quartz. Groundwater in basaltic rock is mainly associated with a weathered zone, fractured zone, and potential intertrappean bed. However, the area under study is not equipped with a healthy amount of subsurface space to store and yield a sufficient amount of water. We have identified few exposures and crosscutting, which impart the idea that the fractured zone and intertrappean beds are very rare in the area, which results in making the subsurface more resistive towards water transport.

Photo 22: *Team while measuring well water level*

Photo 23: *Team while noting the well details*

Photo 24: *Basaltic formation in well*

Since the mountain root and foot side are very compact and contain very few traces of the first interatrappean bed (similar to the catchment area) so the possibility of tapping water is not certain, and those intertrappean beds and gaps are also found dry. It has been reported that the local people in the catchment villages are blindly digging their wells in the hope to encounter any potential layer to tap groundwater but most of them are encountered with the massive and compact formation, which don't yield or transmit water and later on it is being used as storage well.

Photo 25: *The rocky bed of Banganga River in the catchment*

Photo 26: *Basalt rock from dug well*

During well inventory, several dug wells were closely observed to understand the depth and thickness of intertrappean beds and found that the possibility of getting these layers is very less and if encounter any, the yield capacity is very minimal (figure 16).

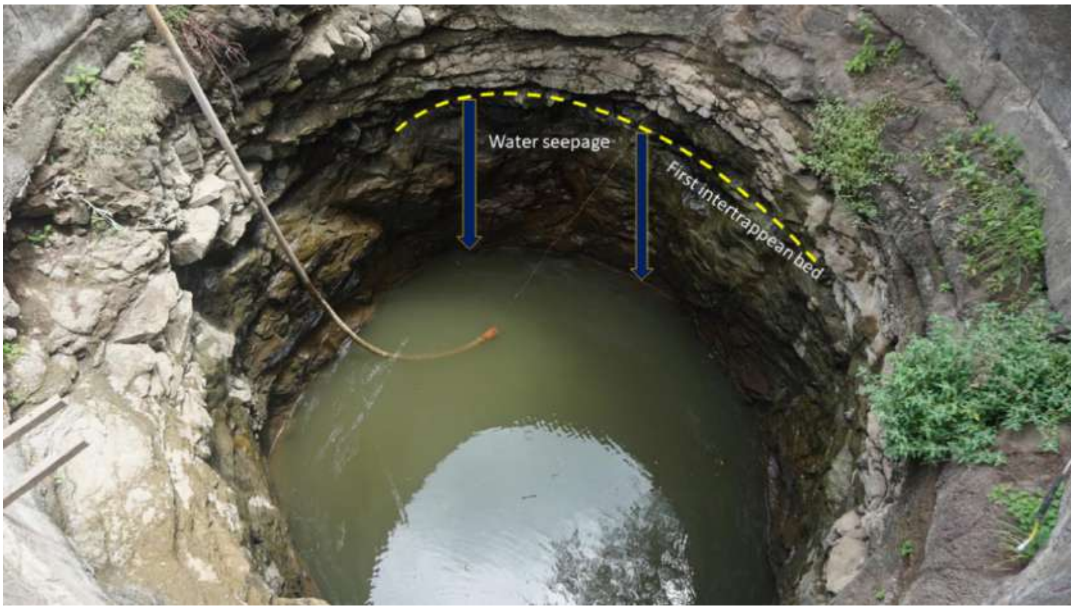

Figure 16: *Cross-sectional view of Dug well to illustrate the water seepage from intertrappean bed*

Geological cross-sections were deciphered to understand the potentiality and compactness of the formation. The cross-section was demarcated near the quarried pond at Manori village, where the first layer of interatrappean was identified, which was sandwiched between two massive layers of Basalt and the yielding capacity was very low in fact on the negligible side (figure 17). Pumps are being used extensively to transport the water from the source to dugwells to meet the deficit.

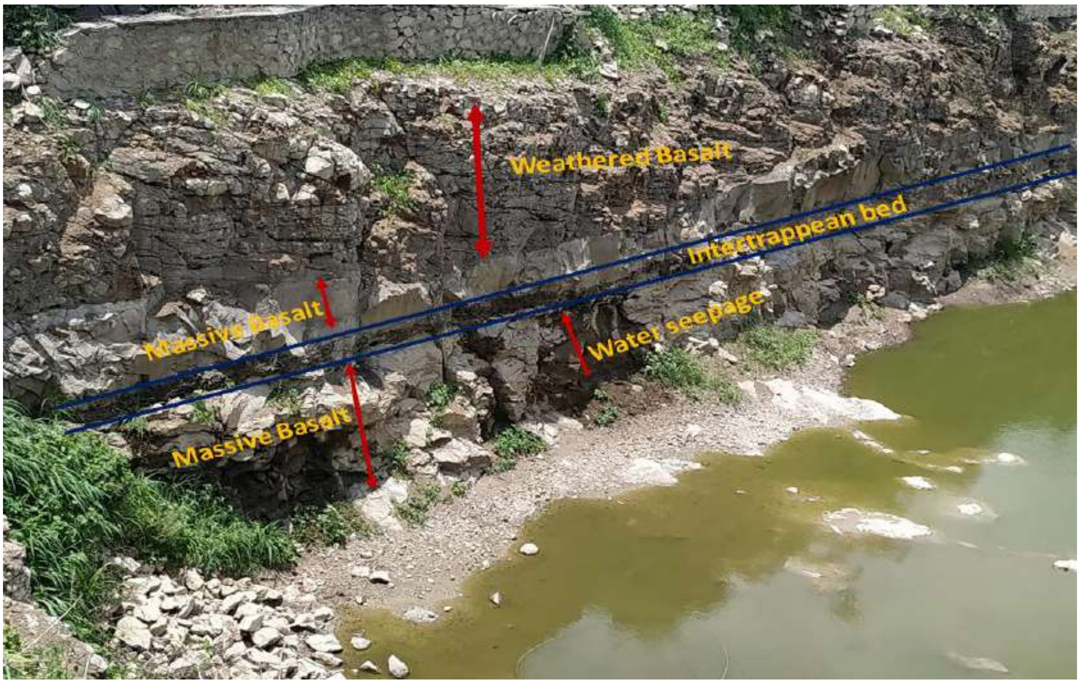

Figure 17: *Cross-sectional view of the subsurface with detailed geological component near a quarried pond at Manori village*

1.4.3 Groundwater scope and use pattern

The Groundwater in the catchment area occurs in the interconnecting vesicles, joints, fractures, and other secondary openings. The lava flow differs greatly amongst themselves regarding their ability to receive, recharge, store and transmit groundwater. Differences in lava flow with respect to their productivity arise as a result of their inherent physical characteristics such as their porosity and permeability.

Groundwater scope and development are linked with several factors viz., precipitation, crop water requirement and overall use, and the performance of aquifers in terms of yield capacity. In the study area, Irrigation is a major shareholder of groundwater and dug wells are mainly used to store and supply the demand. In the area of study, most of the dug wells are storage well and very few wells are self-yielding well and that too very less in amount. They get filled by transferring water from the nearby river and stream. In the month of July and August, water appears in the stream and sustain up to November. Apart from that, counted bore wells were identified in and around the study area, the water level is very deep and the average depth of the bore well is around 350-400 feet, bore well also don't yield much amount of water and is only sufficient for drinking purpose, which runs for 15-20mins with 2-5 hp pump. Many wells run out of water for 2 to 3 months (March-June) in a year and farm ponds are being used to meet the requirement for domestic and irrigation use. The year of monsoon failure makes chaos among the local inhabitants and they get supplied water through pubic tankers.

Photo 27: *Water from irrigation dam being pumped in dugwell in Ashewadi village*

1.5 Growing Industries in the Catchment

In the catchment, industries came in an extensive manner and in red colour in following figure we can see the spread of industrial area in the catchment. As mentioned earlier Godrej NGCARD plant is in the catchment to the bottom of Ramshej fort in Ashewadi village, the other plant of Godrej (Maxximilk) is just outside of the catchment in Jambhutake village.

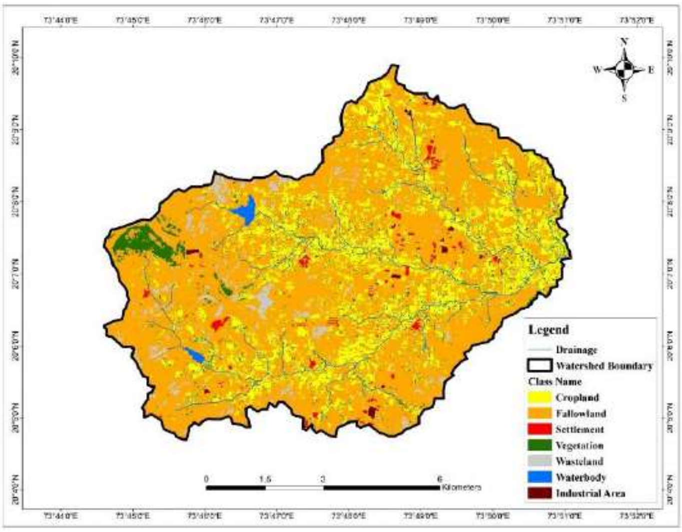

Figure 18: *Industrial areas highlighted on LULC map*

The red marked industrial area in figure 18 is 23.18 ha, and the concentration of the industrial expansion is in the area of Talegaon Dindori and Pimpalnare. The recent important update is that a few areas of Talegaon Dindori and a large area of Akrale village which is downstream in the catchment have come under the Delhi-Mumbai Industrial Corridor (DMIC) project, and the land from farmers is purchased from the farmers and the project is under design phase. As these industries are located in the Grampanchyat of these villages, they are also a good revenue source for these Grampanchyats for taking village development work.

1.6 Agri-marketing

This agriculture belt and the villages in the catchment are well-known for grape cultivation. Therefore, for the marketing of grapes, there is well system established. Few grapes cultivating farmers are tied up with the Sahyadri Farm, one of the biggest well-known Farmers Producers Organisation (FPO) in the Dindori region, and depending on the quality they are getting good rates. Even there number of traders and which approach farmers to purchase the grapes. Sahyadri farm also purchases vegetable crops from farmers and exports them to different places.

Tomato is a major crop cultivated in all the catchment villages, as shared by farmers, almost more than 50% of irrigated farmers in each village cultivate tomatoes. Pimpalnare on the Nashik-Dindori highway is the central place in the catchment, many tomato traders set the temporary sheds for purchasing tomatoes from the farmers on the highway near the village. This place became the centre place for tomato trading. Apart from this few farmers also privately or in groups transport tomatoes to the markets in cities like Nashik, Mumbai, Thane, and even Surat in Gujarat.

The high fluctuation in market rates for tomatoes and other vegetables is the greatest challenge the farmers in the catchment have reported. As these crops are perishable, they cannot be stored for many days after harvesting. Therefore, the suggestions and demand came from farmers for storage houses for tomatoes and vegetables and warehouses for grapes. Even, it is observed very useful to promote small FPOs of farmers in the catchment to deal with these challenges.

1.7 Income and Livelihood Sources

As part of other regions in Maharashtra, agriculture is a top most sector in providing the labour opportunities and source of income in the watershed, however, the industries within the catchment and outside (nearby Nashik city) is also the growing field generating employment opportunity for the people.

Photo 28: *Labouring women engaged in cucumber harvesting*

Horticulture and vegetable cultivation in the catchment area required skilled and continuous work as vegetables, mainly tomatoes, and beans, are being cultivated throughout the year. For tomatoes and other vegetables, making the supportive shed for plants to grow with iron wire and bamboos required hard and skilled work, along with the other cultivation required. Many farmers share that for tomato cultivation, they bring labourers from outside the watershed, many farmers have their pickup vehicles and they use it for picking and dropping labourers from other villages. The daily wage rate for women labourers is approx. 200 rupees out of which 20 rupees have to be given to pick up. Even for grapes cultivation, many farm owners make a contract with labour families for cultivation throughout the season of grapes, and they make living arrangements, groceries, and food grains for these families at their grapes farms.

Dairy and livestock is also very supportive income source for many farmers in the watershed, and farmers also shared that they want to continue this as in cases of increasing events of crop failure and loss as well as market failure for crop rates, dairy provides them the stable income source.

In all these villages, there is an ample number of women SHGs and many are functioning well with support from the Umed scheme by Maharashtra State Rural Livelihood Mission (MSRLM). However, apart from a few individual women taking entrepreneurial activities, no group has initiated any group-level business. Sampada trust has supported backyard poultries through Godrej support for a few women for income generation as well as family intake.

Photo 29: *Woman with her backyard poultry unit in Ashewadi*

Regarding the Godrej plants, local villagers have expectations and demand that few people be get employed in plants for different types of work. We get to know from Godrej Authorities that even they were also positive and made effort initially to give employment to local people, but the experience was discouraging as local employees were giving more focus to farm work, families, and frequent leaves for many reasons (family, social and political events and functions). Therefore, the plant authorities, for not to routine work/schedule hampered, do not prefer the local people for employment/daily work.

The key livelihood opportunities which will be useful to be promoted in these villages are,

i) **Dairy and Livestock:** Focusing on small and medium farmers, and even big farmers. In increasing events of crop failure and volatile markets, this can provide assured income to vulnerable families.

ii) **Organic input production units**: Local youth can be trained and supported for mass production of vermicomposting, vermi-wash, organic formulations for spray. This will generate employment, with the added advantage to promote and improve the deteriorating soil health in the watershed

iii) **Farmer Producers Organisations (FPOs):** As the catchment is close to Nashik and Dindori city as well Gujrat state, there is a huge market potential for vegetables and other crops. Therefore these farmers can be organized, capacitated, and supported for forming a few FPOs which can enhance their income, as well as further their capacities, can be developed for sustainable agriculture practices.

iv) **Small scale entrepreneurship development/businesses for Women SHGs:** Many women are already organized in different SHGs in catchment villages, and their confidence and spirit of cooperation are developed at a fair level. We can build on this and be organize, capacitate and support women to take different entrepreneurship development activities.

1.8 Scale and status of WASH services

In table 7 village wise details of water availability and quality for drinking water is presented, along with the required solutions to the problem

Photo 30: *Solar powered unit for public drinking water well in Ashewadi*

Table 7 WASH status in the catchment villages

Village	Drinking water sources/infrastructure	Quality issues	Need/demand by villagers	Proposed interventions
Ashewadi	-Ashewadi Tank and dug well. The dug well pump is solar energy powered, but the solar unit is not being used properly. –In summer, there is a weekly water supply and therefore tanker dependency.	-Water quality is average, runoff water from stream get directly percolated in dug well. -Water ATM in the main settlement, but all hamlets don't get the benefit. Few families purchase private water cans with a monthly expenditure of around Rs.1000	-Water RO plant at different hamlets -Piped water supply to hamlets	Water RO plant/purification units in few main hamlets
Dakhambe	-Water is lifted from the canal (4 km away) to the drinking water well. -Additionally, the small tank near the drinking water well gets filled by canal water, and this backup water also gets utilized during scarcity periods. -Still, villages face water scarcity after April and depend on tankers	Water gets supplied to households by tap connections after the proper treatment	Need more water available for water shortage period of 2 months	The tank near the dug well can be turned into a plastic-lined farm pond to get water stored for more period
Talegaon Dindori	-Depend on dug well and bore well within the village - Additionally, drinking water is being imported through the pipeline from 5 km from Rantala and stored in the overhead tank and then further distributed through tap connections, however, the huge cost of electricity bills is the challenge	Water ATM installed and water good quality	Need of assured water sources need for the summer period	Maybe recharge shafts possible near drinking water well

	-Frequently face water scarcity, and hence depend on tanker			
Manori	-Tap water supply to households -Water stored in farm ponds and tanks gets used for livestock as well as for drinking. -Tanker never required in the village.	OK	NO	NO
Pimpalnare	-Piped water supply to all villages throughout the villages with perennial water source from Pimpalnare dam	Water ATM installed in the village and most villages are benefiting	NO	NO
Khatwad	-Most families settled on farms and avail water from their sources -In village water is available for almost throughout the year	Water quality in the village is not to the satisfaction and only marginalized and vulnerable families live in the village	Water RO unit can be supported	Water RO plant/purification units in few gaothan/main village
Ambe-Dindori	Water is available throughout the year to well	Water ATM installed, but as the number of families is more, the unit is not sufficient to provide water for all	Additional RO unit needs to be installed	Additional RO units can be supported

Mining and stone crushing units in the catchment are increasing and creating a threat to drinking water sources. For example, in Ashewadi village, water quality is very poor because, in the deep quarries of stone mining, the rainwater runoff gets arrested and directly percolated in the aquifer, without any natural filtration and affecting the groundwater quality. Therefore women from Ashewadi shared that, they tackle the situation as per their capacity by filtering, boiling, purchasing filtered water, or fetching water from neighbour's wells. Apart from Talegaon Dindori, no drinking water well was covered and was open.

The drainage system is mixed, partially open, and partially closed in these villages, and sewage from villages directly gets flooded in streams nearby villages. Most villages are under a total sanitation program, in the village, there is no system of community toilets but it has been reported that almost every household has a toilet constructed and around 80 to 90% of families use these toilets.

1.9 Issues of concerns of Women in the Catchment

Self Help Group movement is successful at a good level in mobilizing many women in the catchment. In Ashewadi there are altogether 19 women SHG groups, and Talegaon 17 groups. In each rest of the villages, SHGs are good number and women are mostly involved saving activity. It is reported that all groups are not functioning or active at the same level, few are non-functional, but few of them have made good progress. The active groups have received a good amount of incentives and subsidies from Government programs, Panchayat Samite, and the Umed scheme under MSRLM.

Apart from saving, few SHGs have initiated small businesses and income generation activities. In Talegaon Dindori, women started a small business of homemade food item making but with the imposition of lockdown it was closed, however, some of the women received training on tailoring and in lockdown period initiated preparing masks and selling them to different governments and non-government organizations. Even a few women in Ashewadi started the business of backyard poultries. Women in most villages reported satisfaction with water availability for domestic purposes but were not very happy with water quality where many families are not benefiting from the water ATMs.

Photo 31: *Solar-powered unit for drinking water supply in Khatawad village*

The important point to note here is the social problems they face in the catchment villages. Although many women are active and organized in SHGs, they are not a member and are not active in water management institutions, mainly water user associations functioning in many villages. Apart from this, women shared the problem they facing of family and community level conflicts and disputes due to liquor consumption by men. Women in Talegaon Dindori, Ashewadi, Pimpalnare villages categorically shared that, agricultural prosperity, more income, and livelihood opportunities also came up with the practice of frequent liquor consumptions. As the Nashik and Dindori cities are very close to these villages, there is easy access to the liquor shop to people, and even there are few shops at the nearby highway. As shared by women, few of the problems of family disputes and even a few drunken men in hamlets and villages use to make dispute any small issues, affecting their free mobility outside and resulting in mental stress.

Chapter 2. Existing water harvesting and groundwater potential in the catchment

By mapping all surface water bodies, water imported outside the catchment for irrigations, and assessing groundwater potential this chapter presents the overall water balance (water inflows and outflows) for the catchment as well as the Godrej plant.

2.1 Existing total surface water harvesting/augmentation potential in the catchment

This subsection provides the details of all major and minor surface water bodies in the catchment in terms of their total potential to harvest water and the actual capacity of these structures. The map is shown below presents the all water bodies available in the catchment, mainly Irrigation dams, Earthen bunds/percolation tanks, cement check dams, Banganga river which originate from Ashewadi dam and flow throughout the catchment, and major draining/stream network as shown in figure 19.

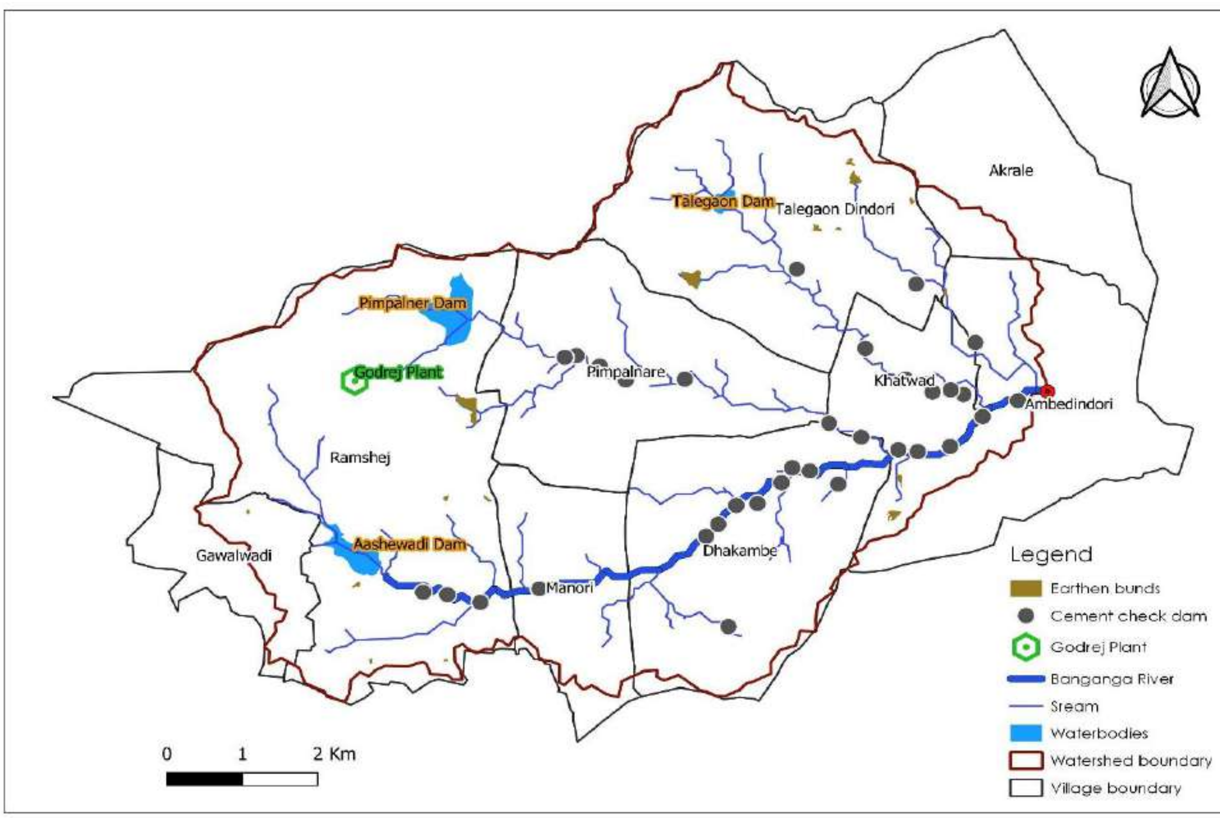

Figure 19: *Surface water harvesting structures in the catchment*

2.1.1 Irrigation dams

As shown in figure 19, there are 3 major irrigation dams in the catchment. The largest water body is the Pimpalnare dam which is minor irrigation dam under the water resource department. The other two irrigation dams are one each in Ashewadi and Talegaon Dindori. The storage capacity and the water spread area, along with beneficiary villages of these dams are presented in table 8. Thus the total water storage capacity of 3 irrigation dams altogether is 419.83 Crore liters.

Figure 32: *Heavily silted irrigation dam in Talegaon Dindori*

Table 8: Details of irrigation dams in the catchment

Sr. No	Name of Dam	Land Under Water Storage in Ha.	Storage Capacity in Crore liter	Beneficiary villages
1	Pimpalnare	64	219.78	Farmers in Pimpalnare village are the main beneficiary and they manage the dam through WUAs. If the dam get overflow, then flow adds to the stream and then to Banganaga river benefiting farmers in downstream villages, Khatwad, Dakhambe, and Ambe Dindori
2	Ashewadi	38.46	162.25	Ashewadi dam is the important water source for Manori and Ashewadi village for irrigation and domestic water
3	Talegaon Dindori	12.6	37.8	This dam is in the upper area of the village and it benefits nearly all farmers through groundwater benefits and few farmers directly lift the water. However, the water spread area is encroached by the farm owner and he is cultivating periodically in it.
	Total	**114.56**	**419.83**	

2.1.2 Percolation Tanks and Earthen bunds:

Percolations tanks, village ponds, and big earthen bunds are old structures, mainly constructed through Employment Guarantee Scheme in the 1970s and 80s. Groundwater benefits through percolations, water flows for the increased period downstream, increased water for drinking and domestic purpose and direct lifting for irrigation purposes are a few important benefits of these structures. In The catchment, there are a total of 18 such water harvesting structures with a total capacity of 45.29 Crore liters. As most of these structures are deposited with silt and therefore we have for calculating catchment water balance we have considered the 70% of the utilizable capacity of total potential, i.e. 31.70 Crore liters. All relevant details and calculations of these structures are presented in table 9.

Table 9: Details of Percolations tanks, village ponds, and big earthen bunds in the catchment

Sr. No	Village Name and EB No.	Area in Ha.	Storage Height	Total Volume (Crore Lit))	Utilizable Storage (70%) in Crore Lit
1	Talegaon Dindori-1	4.53	3	13.60	9.52
2	Talegaon Dindori-2	0.79	2	1.58	1.11
3	Talegaon Dindori-3	0.28	2	0.55	0.39
4	Talegaon Dindori-4	0.48	2	0.96	0.67
5	Talegaon Dindori-5	1.96	2	3.92	2.75
6	Talegaon Dindori-6	0.21	2	0.42	0.29
7	Talegaon Dindori-7	0.53	2	1.06	0.74
8	Talegaon Dindori-8	0.70	2	1.4	0.98
9	Ambedindori-1	0.56	2	1.11	0.78
10	Ambedindori-2	0.83	2	1.66	1.16
11	Ambedindori-3	1.66	2	3.31	2.32
12	Gawalwadi-1	0.27	2	0.55	0.38
13	Ashewadi-1	0.41	2	0.81	0.57
14	Ashewadi-1	0.55	2	1.09	0.77
15	Ashewadi-1	0.23	2	0.46	0.32
16	Ashewadi-1	0.19	2	0.39	0.27
17	Ashewadi-1	0.44	2	0.89	0.62
18	Ashewadi-1	5.76	2	11.53	8.07
	Total			**45.29**	**31.70**

2.1.3 Cement Check dams

There are a total of 33 cement checkdams in the catchment, mainly on the Banganga River, spread in Ashewadi, Dakhambe, and Khatwad, and Ambe-Dindori (figure 20). These check dams are important in arresting the runoff and increasing the groundwater potential in surrounding wells. Most check dams are non-gated but few are gated in the catchment. We did an extensive survey of each checkdam with noting its dimensions to calculate the volume and assessing its quality to harvest the runoff in the stream/river.

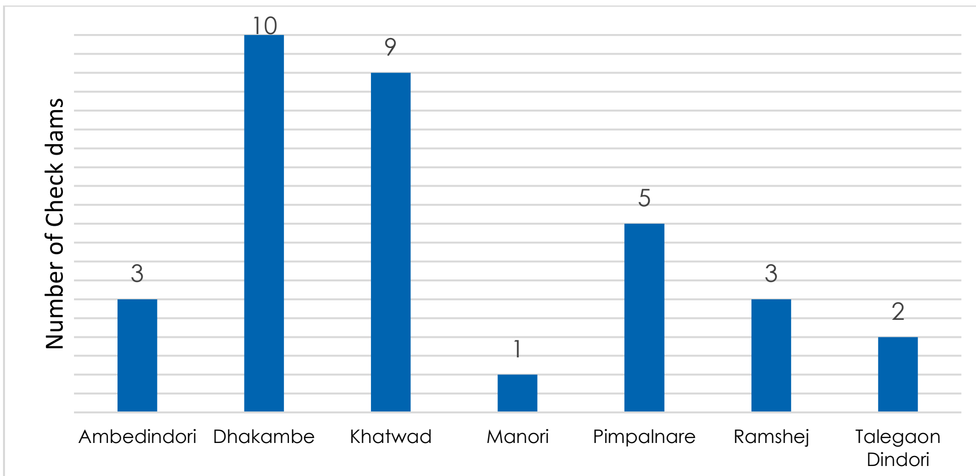

Figure 20: *Spread of Check-dams in catchment villages*

Table 10 explains the dimensions of all check dams, their water harvesting potential, and the status of quality to harvest the rainwater. Although the total water harvesting potential of these 33 check dams is 25.28 Crore liters, depending on the status of the check dam we have calculated the actual water harvesting capacity of the chekdams (21.43 Crore liters) for calculating the water balance of the catchment.

Photo 33 and 34: *Team members while taking measuring the dimensions of checkdams to calculate the potential*

Table 10: Details of existing Check-dams

Sr.No.	Village Name	Check dam No.	Length of Structure in M.	Avg Depth in M	Avg Width in M.	Water Spread Length in M.	Total Water Storage (Cum)	Total Water Storage Crore liter	Quality/Status of Structure	Percent use in	Actual storage in Crore liters
1	Ambe Dindori	1	60.4	0.87	34.17	350.00	10363.89	1.04	Good	100	1.04
2	Ambe Dindori	2	53.2	3.10	41.16	370.00	47206.70	4.72	Good	100	4.72
3	Ambe Dindori	3	48.4	4.50	36.13	410.00	66666.00	6.67	Good	100	6.67
4	Ambe Dindori	4	39	1.93	33.00	270.00	17226.00	1.72	Wall damaged/leakage	50	0.86
5	Ambe Dindori	5	41.8	1.02	30.07	350.00	10698.72	1.07	Wall damaged/leakage	30	0.32
6	Ashewadi	1	13	1.33	11.67	50.00	777.78	0.08	Good	100	0.08
7	Ashewadi	2	13	1.35	10.67	60.00	864.00	0.09	Wall damaged/leakage	0	0.00
8	Ashewadi	3	35	0.47	29.37	80.00	1096.36	0.11	Wall damaged/leakage	0	0.00
9	Ashewadi	4	15	0.53	16.23	140.00	1212.09	0.12	Wall damaged/leakage	0	0.00
10	Ashewadi	6	20	3.20	15.33	35.00	1717.33	0.17	Wall damaged/leakage	0	0.00
11	Ashewadi	7	50	2.20	28.63	40.00	2519.73	0.25	Good	100	0.25
12	Ashewadi	8	40	1.03	13.97	50.00	721.61	0.07	Wall damaged/leakage	0	0.00
13	Ashewadi	9	35	2.03	12.73	60.00	1553.47	0.16	Good	100	0.16
14	Dhakambe	1	28.45	0.90	23.47	95.00	2006.40	0.20	Good	100	0.20
15	Dhakambe	2	23.4	0.97	21.80	170.00	3582.47	0.36	Good	100	0.36
16	Dhakambe	3	27.5	2.50	33.67	270.00	22725.00	2.27	Good	100	2.27
17	Dhakambe	4	40.8	0.48	30.27	200.00	2925.78	0.29	Wall damaged/leakage	0	0.00

Sr.No.	Village Name	Check dam No.	Length of Structure in M.	Avg Depth in M	Avg Width in M.	Water Spread Length in M.	Total Water Storage (Cum)	Total Water Storage Crore liter	Quality/Status of Structure	Percent use in	Actual storage in Crore liters
18	Dhakambe	5	23.4	1.03	21.20	180.00	3943.20	0.39	Wall damaged/leakage	50	0.20
19	Dhakambe	6	18	1.03	17.00	65.00	1141.83	0.11	Wall damaged/leakage	30	0.03
20	Dhakambe	7	35.8	0.92	15.67	60.00	861.67	0.09	Wall damaged/leakage	0	0.00
21	Gawalwadi	1	20.4	2.77	17.90	65.00	3219.02	0.32	Good	100	0.32
22	Gawalwadi	2	20.4	1.10	14.13	46.00	715.15	0.07	Silt deposited	0	0.00
23	Khatwad	1	15.4	1.33	14.32	150.00	2863.33	0.29	Good	80	0.23
24	Khatwad	2	15.4	1.27	13.47	140.00	2388.09	0.24	Good	100	0.24
25	Khatwad	3	27	1.77	25.33	80.00	3580.44	0.36	Wall damaged/leakage	0	0.00
26	Khatwad	4	19.4	1.60	15.03	270.00	6494.40	0.65	Good	100	0.65
27	Khatwad	5	30.9	1.30	26.93	310.00	10854.13	1.09	Good	100	1.09
28	Khatwad	6	22.4	1.47	38.27	250.00	14031.11	1.40	Good	100	1.40
29	Manori	1	25	0.78	21.67	85.00	1436.50	0.14	Silt deposited	40	0.06
30	Manori	2	14	0.43	11.33	30.00	147.33	0.01	Silt deposited	100	0.01
31	Manori	3	30.8	3.00	15.46	120.00	5565.60	0.56	Silt deposited	50	0.28
32	Talegaon - Dindori	1	17	0.93	17.33	50.00	808.89	0.08	Silt deposited	0	0.00
33	Talegaon - Dindori	2	17.4	1.13	17.13	45.00	873.80	0.09	Silt deposited	0	0.00
	Total						**252787.82**	**25.28**			**21.43**

Photo 35: *Checkdam silted by reducing the storage capacity*

Photo 36: *No gates to gated checkdam therefore no water*

2.1.4 Farm ponds

In the catchment area, there are significant numbers of farm ponds, as discussed earlier as the groundwater potential is poor in the catchment, irrigating farmers are using these plastic-lined farm ponds as a backup for irrigation, filled by lifting groundwater and from canal water. We have mapped all farm ponds spatially in the catchment with remote sensing and satellite images and also collected the data of these farmponds from the government department (agriculture department, Dindori) to validate the analysis. The spatial analysis revealed that there are a total of 421 farm ponds in the catchment (figure 21). It is found that the number of farm ponds is considerably high in lower catchment villages than in upper catchments. One of the lower catchment villages Dhakambe is having 127 farm ponds, the highest among all villages in the catchment, this is followed by Talegaon Dindori village which has 91 farm ponds. Gawalwadi an upper catchment village has the least number of farm ponds (only 2) as shown in figure 22.

Total water storage capacity is also calculated for all farm ponds as shown in figure 23. The water storage capacity of farm ponds is highest in Dhakambe village (425322 m^3) since it has the highest number of farm ponds. The lowest storage capacity is found in Gawalwadi (5538 m^3). The total volumetric storage of water by farm ponds is 148.34 Crore liters (1.48 million m^3) in the catchment.

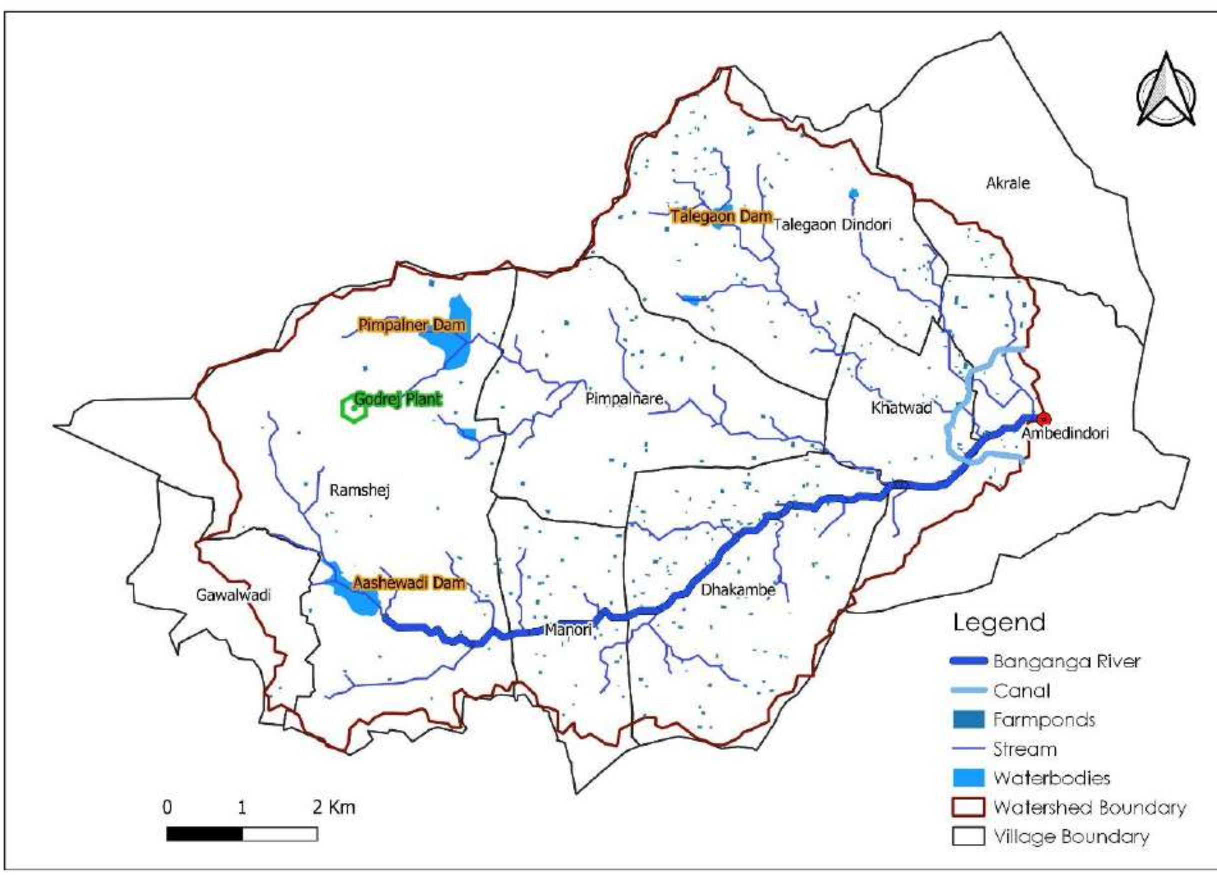

Figure 21: *Farm pond spatial distribution map of the catchment*

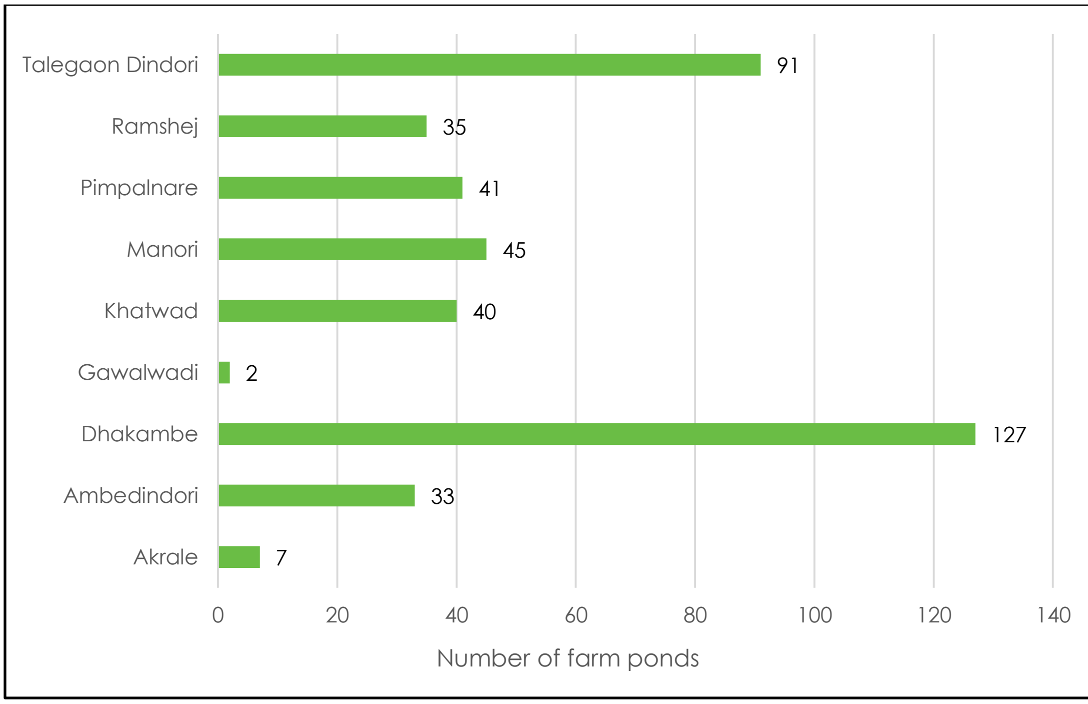

Figure 22: *Village-wise farm pond distribution in the catchment*

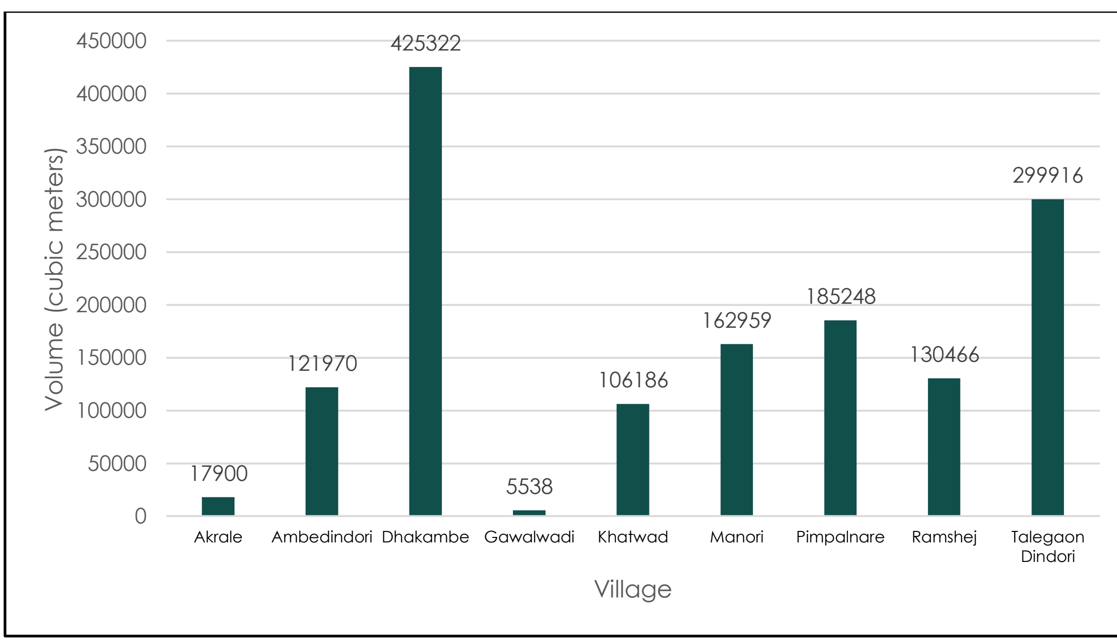

Figure 23: *Village-wise total volumetric capacity of farm ponds in the catchment in m^3*

2.1.5 Water import by water user associations through canals and lift irrigations schemes

As discussed in an earlier chapter, in total there are 12 WUAs functioning in the catchment benefiting from tanks and irrigation projects within the catchment and even outside. Here we present the details of the WUAs which are importing the water from outside the catchment. In total 7 WUAs and 1276 farmer-members benefits by water import through canals and minor distributaries from Waghad dam, one of the medium irrigation project in the Dindori block (refer table no. 6). The canal from the dam passes through the Khatavad village and some parts of Ambe-Dindori village. These farmers directly benefit from the canals through WUAs, in Khatwad, Ambedindori, Dakhambe, and Talegaon Dindori. The farmers receive 6 to 7 rotations of canal water throughout the year, and many farmers fill their big-size farmponds as a backup from the canal water. In total estimated annual water import from the Waghad dam by farmers is 165.24 Crore liters.

2.2 Groundwater potential in the catchment

This section specifically focuses on findings from the geohydrological survey, the rock and aquifer characteristics, and groundwater potential and opportunities in the catchment.

2.2.1 Geological formation

The geological map is generated under the Arc-GIS environment to understand the lithological variation with detailed tectonic features like dyke and lineament. Deccan trap basalt is a dominant rock in the catchment area which was formed from the outpouring of magma through a reunion hotspot (figure 24). As per the observation, the catchment is flourished with a healthy amount of lineaments and counted dykes were also marked in the area. Since the dykes are major across the drainage line so it may act as a barrier for the downstream aquifers to make the upstream more potential in terms of groundwater exploration. Lineament distribution can be seen across the catchment and the higher density of network falling in Pimpalnare which creates scope towards groundwater recharge by artificial means.

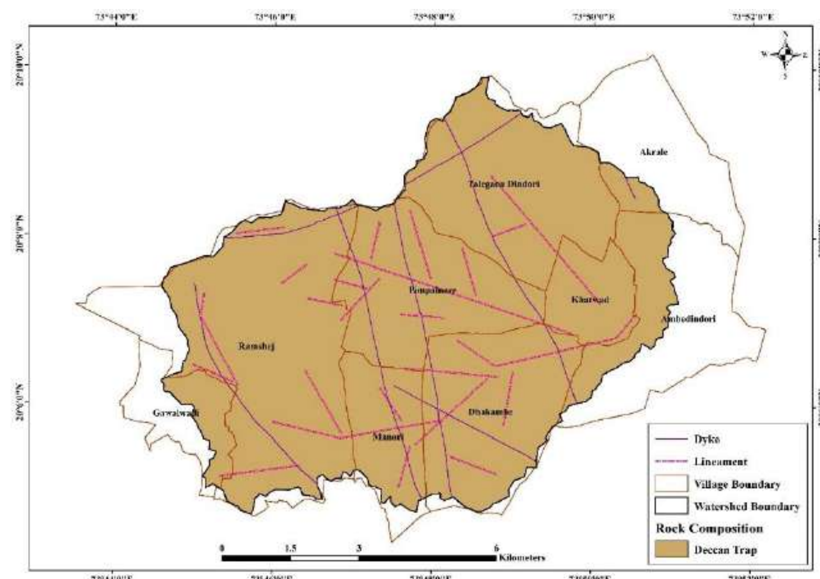

***Figure 24**: Geology map with the tectonic features superimposed with village boundaries* (Data Source: BHUKOSH)

2.2.2 Scale of groundwater structures (dug wells and bore wells)

The scale of wells in the catchment villages is huge. As reported by farmers in group discussion, in Dakhambe there are around 600 wells and Ashewadi has 100 dugwell, and each farmer has at least 1 to2 borewells. The reported wells in Manori villages are 200 dugwell, 215 in Khatwad, and in Talegaon Dindori village each farmer has a minimum of one bore well and one dug well (518 families in Talegaon Dindori village).

Yields of Dugwells and Borewells depend upon the permeability and transmissivity of the aquifer, which plays a major role in the characteristics of the aquifer. The major extracted structures in the area are mainly dug well, bore well, and tube well. The area is primarily thrived with dugwells (>97%) with a counted scatter of borewells, and the yield of the bore well is at the minimal side with the deeper water level and the average depth of bore well is around 350-400feet. borewell capacity much amount of water and is only sufficient for drinking, which runs for 15-20mins with a 2 to 5 hp pump. We have not encountered any tube wells in the study area, however, farm ponds are being used frequently to meet the requirement for domestic and irrigation use. The year of monsoon failure makes chaos among the local inhabitants and the supply of water through tankers pools their gaps for survival. In the area of study, most of the dug wells are storage well and very few wells are self-yielding well and that too very less in amount. Therefore, as reported by farmers, Groundwater Survey and Development Agency (GSDA is a state agency) have clearly recommended block-administration of Dindori not to sanction any dugwell in the catchment villages through any government scheme. GSDA has cleared that the groundwater yield in shallow aquifers is very poor, the investment in dugwell is of no means. Therefore, farmers fill the dug well by transferring water from the nearby river and stream. In the month of July and August, water appears in the stream and sustain up to November.

2.2.3 Groundwater yield

The borewells and dugwells in the area are not so deeply drilled, it goes down to 70 m depth, tapping weathered and vesicular basalt which gives the yield range of 18 to 68 m 3 /day. This variation of yields in the single type of aquifer is due to lateral/spatial variation in permeability of the formation/aquifer material. The yield range of the Alluvium well is of 13-22 m^3/day whereas the dug well yield of Basaltic terrain ranges from 45 to 90 m^3/day.

2.2.4 Groundwater Recharge and Discharge zones

In an undulating terrain of basaltic rock, the identification of groundwater recharge and discharge zones are very challenging. However, demarcation of potential recharge and discharge zone is of major concern for groundwater development and management in the area of this study. In order to generate the above-said layers, we did a geohydrological survey in and around the catchment villages to understand the general trend of water level and its response to the precipitation. A total of more than 200 wells were geotagged and monitored for water level fluctuation in the catchment. Three different layers are generated to understand the groundwater scenario comprehensively, viz; groundwater flow map, grid vector map, and combined grid and groundwater flow map. Further, the recharge and discharge map is compared with the detailed groundwater potential map we generated for the catchment with the support of GSDA online village maps and data support (GSDA, 2021).

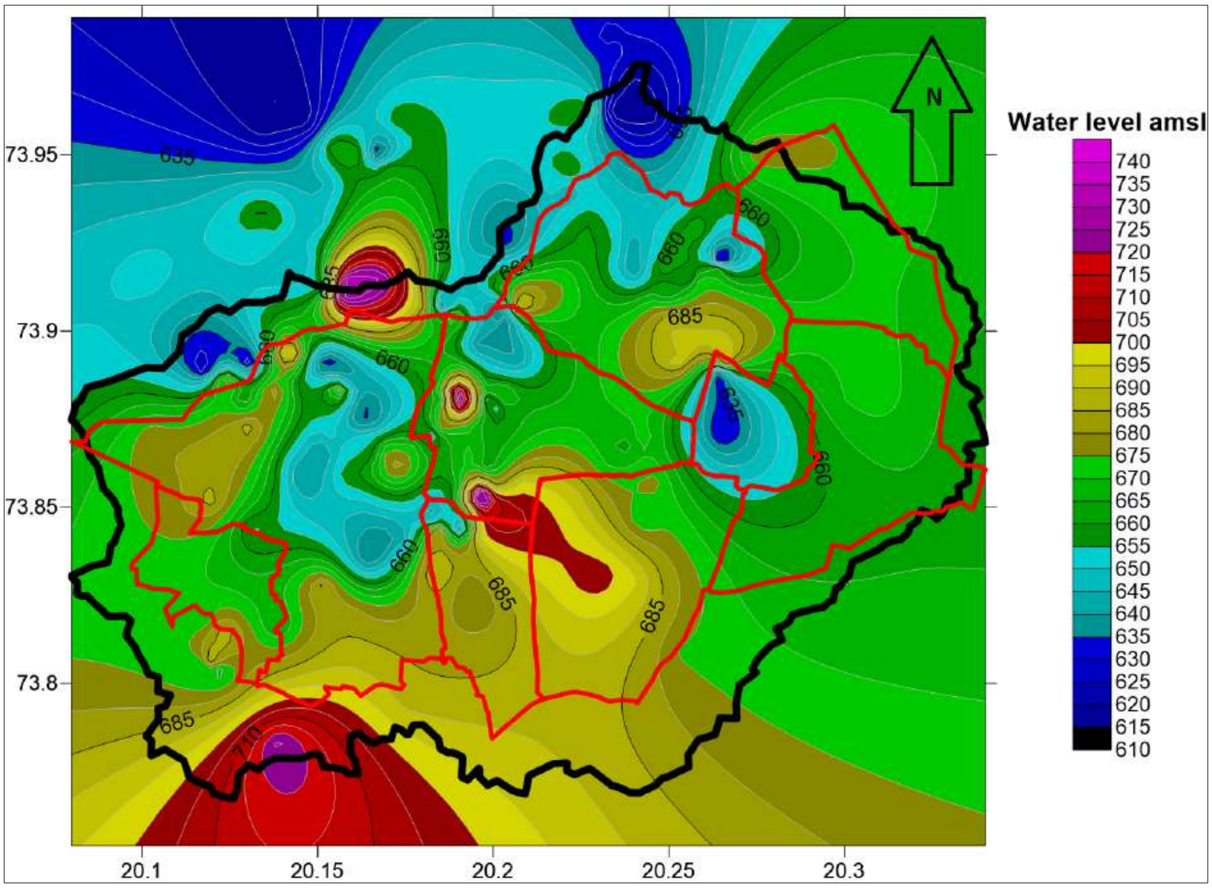

Figure 25: *Groundwater level flow map in terms of contour above msl.*

Groundwater flow map deciphers the general slope trend of water below the surface, kriging method is used with the contour interpolation by connecting equal values of water level on the Surfer-14 platform (Figure 25). The purple and red patches stand on the higher side and go down towards blue patches, which indirectly justifies the theory that the water level follows the topography. The area is flourished with several small to medium mounds and flat-topped topography, the occurrence of water in this terrain is mainly confined in the weathered zone or intertrappean bed. However, intertrappean beds do not have much potential in terms of water yielding capacity and the weathered basalt are responsible to transport and store water.

Groundwater level modeling was carried out under the surfer environment to observe the groundwater trend within the catchment. Some spots have been encircled as per the water plume and depressed zone to understand the water fluctuation comprehensively. The higher peaks encircled with red in the model demonstrated the deepest water level, however, the depressed zone encircled with blue attributed to the shallow water level stored in the well. Several highs and lows can be observed in the model, which clearly depicts the scenario that the connectivity among wells is not prominent, hence, the groundwater flow is reckoned as very complex in the catchment area (Figure 26).

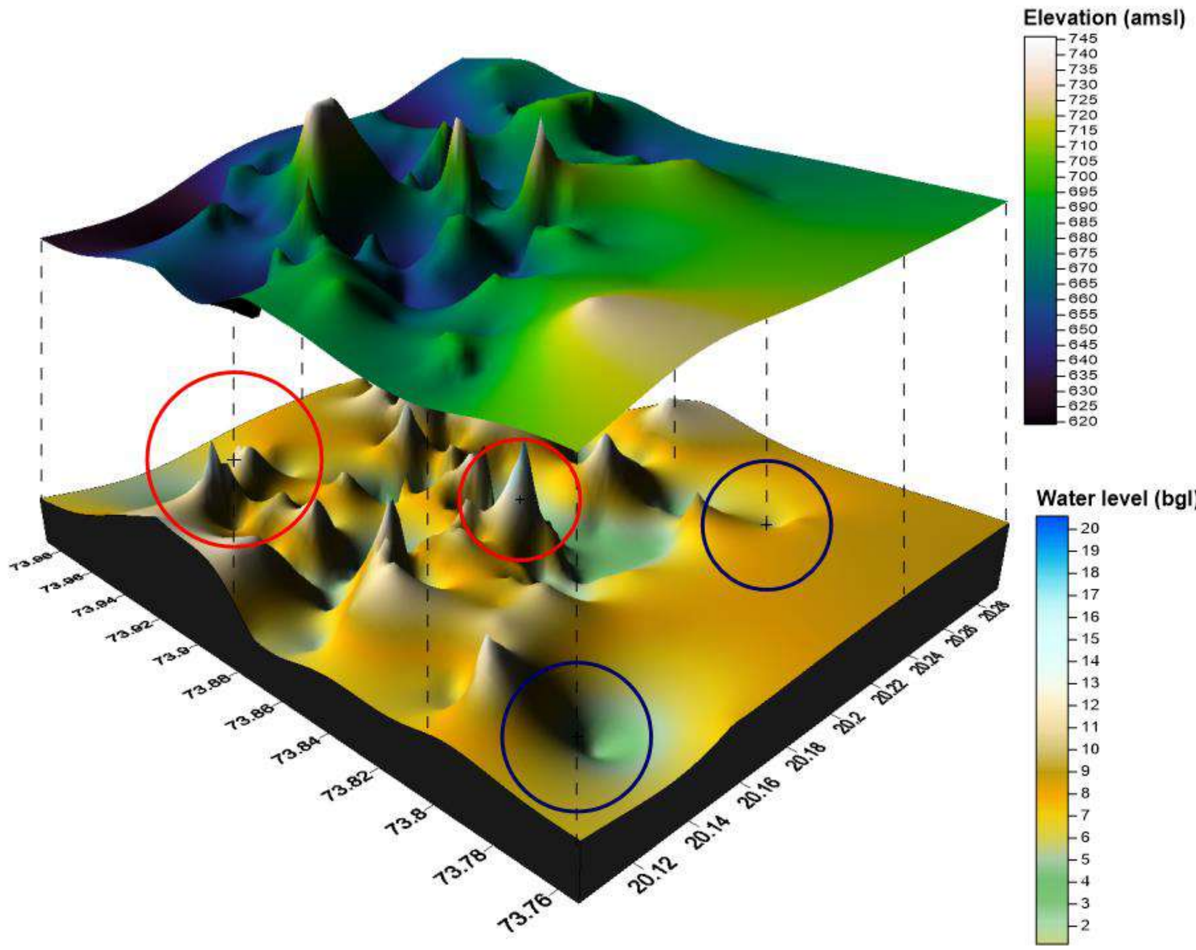

Figure 26: *3D Groundwater level stacked model in the form of the plume and depressed zone.*

In order to get the flow direction, a grid vector map was generated to recognize the gradient of the area in terms of groundwater recharge and discharge zone (Figure 27). However, wells in the area are mainly storage well so the recharge and discharge will not be the appropriate term in this scenario, rather we can take it as a water plume and depressed zone on a utility basis. The blue circle can be seen with the vector convergence, impart the idea about the movement of water at a centre point with a cone of depression, and can be identified as a discharge zone. On the other hand, the black circle can be observed with the gradient moving away from the centre point, gives an idea of the water plume flowing outside, and can be articulated as a recharge zone. In comparison with the existing map of GSDA, it's been found that the discharge zones are mainly falling in the area of clustered wells (in Ashewadi, Manori, and Khatwad villages) and the recharge zones are following the same suitable zones as enumerated in the GSDA map (Ashewadi, Talegaon Dindori, and Dakhambe villages) for using it as a favourable zone for artificial recharge (Figure 28).

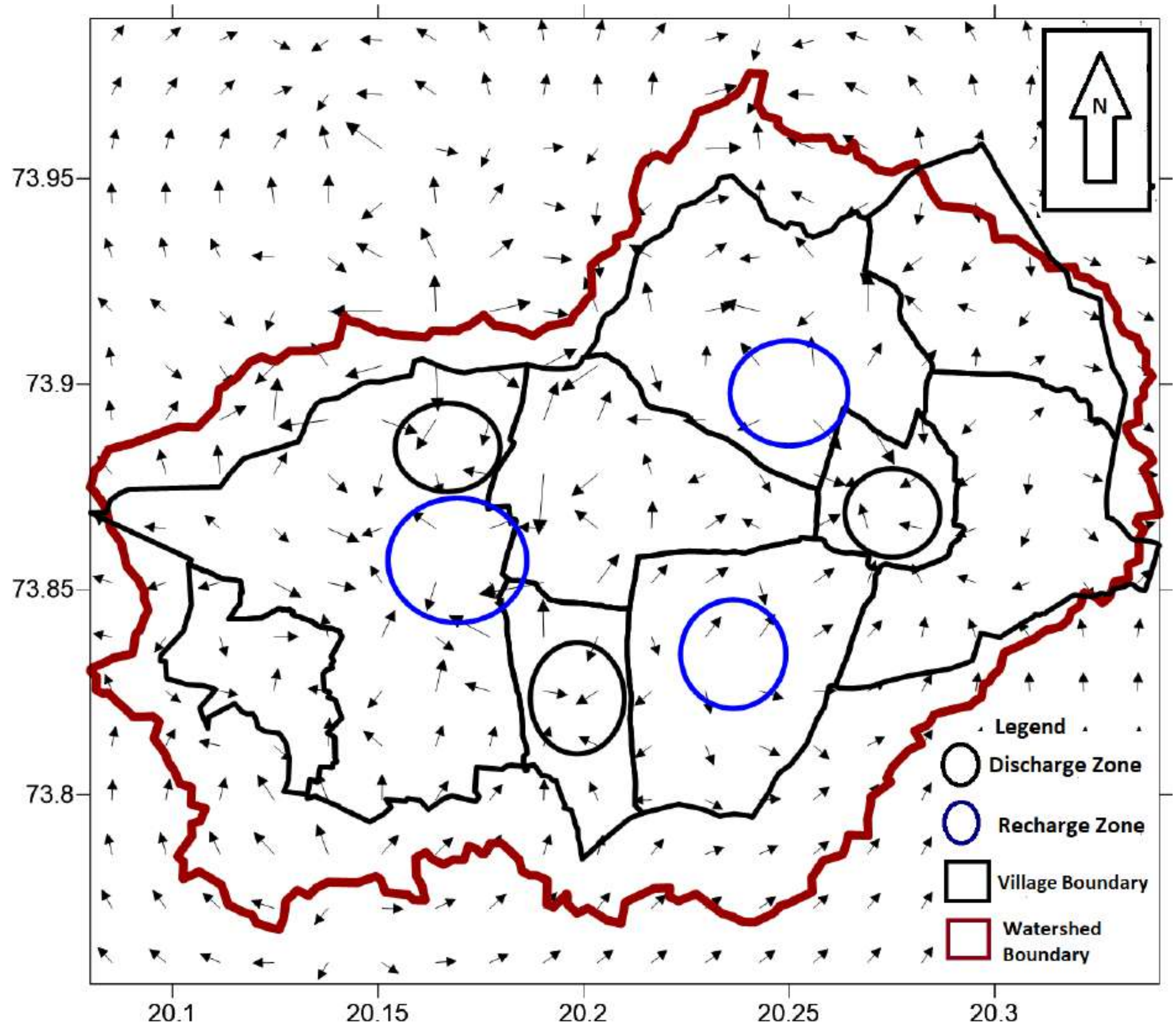

Figure 27: *Grid vector map with the superimposed village boundary and recharge discharge zones.*

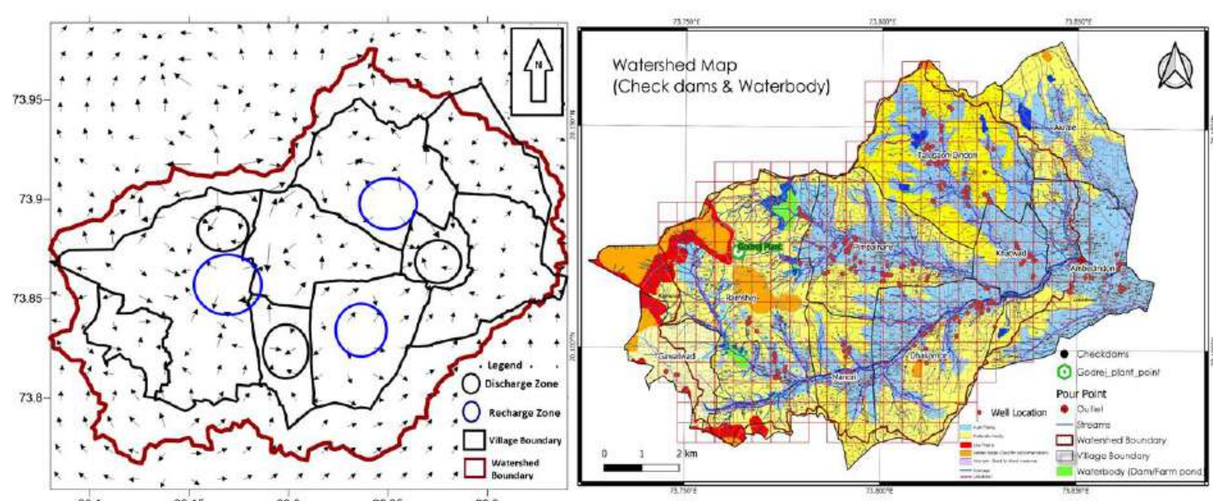

Figure 28: *Comparative analysis between observed data and existing map (Source: GSDA).*

2.2.5 Potential annual groundwater stock/availability

90% of the district is occupied by the Basaltic flow in the Deccan trap and the catchment delineated follows in this zone. The occurrence of groundwater in this Deccan trap is mainly associated with the weathered zone and fractured zone, which goes down to a depth of 32m. Groundwater in upper weathered formation is under unconfined conditions, however, the deeper fracture and intertrappean beds are under semi-confined to confined conditions (CGWB, 2020). The yielding capacity of the dug well ranges from 10 to 100m3/day whereas bore well capacity ranges from 02 to 2.5 lps (liters per second). Central Ground Water Board (CGWB) and Ground Water Survey and Development Agency (GSDA) have together estimated the groundwater resources by recharge potential applying GEC-1997 methodology for different geologies. According to the GEC-1997, the recharge value of rainfall for the geology which follows the geology in the catchment which is 'Weathered granite gneiss and schist with significant clay content' is 3% (CGWB, 2014). The catchment receives 781 mm annually and the catchment area is 6688 ha. Therefore with the 3% of rainfall recharge for the catchment, the groundwater resource availability is calculated 157 Crore liters (3% of 5223 Crore liters).

2.3 Water balance of the catchment

Here, we present the important analysis of the study of the water balance /budget of the catchment. The water balance analysis is made by applying the water budgeting tool developed by WOTR in the last few years and modified with new learnings with wider application in different project villages. This tool is also in line with the water budgeting tool developed by the Maharashtra government for the Jal Swarajya and PoCRA projects. The water balance for the catchment is made at two levels, for the current year considering the annual average rainfall, and with future projections considering changing rainfall for the next 30 years.

2.3.1 Catchment water balance for the present condition

The basic principles and processes followed in water budgeting tool is that of total rainfall, part of it get arrested in the soil as soil moisture, some get percolated as groundwater, some amount gets arrested in soil and water conservation structures, few of it gets evaporated, and rest get flooded out as runoff out of the watershed or catchment boundary. The water balance is calculated with the average rainfall recorded in the catchment available at different secondary sources that are 781 mm, for water balance studies average rainfall gets factored, acknowledging there could be high rainfall or less rainfall during next coming years. Therefore the total rainwater available in the catchment area of 6688 ha. with 781 mm rainfall is 5223.33 crore liters. However out of these, a significant amount of water gets flooded out as runoff from the catchment and few amounts get evaporated, therefore while securing drinking water for the catchment actual water is available for different uses in form of soil moisture, groundwater, water harvested in structures, and water getting imported from outside the catchment is considered is 1592.25 Crore liters. Thereafter different demands and use of water is calculated in terms of water required for drinking and domestic purpose, commercial and business purpose, and more importantly for different crops getting cultivated during the different season, this is called the total water requirement. The total water requirement gets calculated two times, during Kharif season and crab season.

The result of the water balance exercise indicates that the water security index for water use in the Kharif season is safe. The Kharif water use index is below is (0.84), which means total water available in the village is more than the water use required for different uses (Kharif crops and perennial crops). The water available in the village for different uses for a year is 1592.25 Crore liters and the water requirement for Kharif crops and other uses is 1331.65 Crore liters, with surplus water of 260.60 Crore liters for the rest of the seasons (Rabi and summer). However, after the Kharif season, when it comes to Rabi and the summer season, the deficit is found in the water availability and water requirements. The water use index for Rabi and summer crops is observed at 1.54 where water available for Rabi and summer crops is 260.60 Crore liters and the water required 471.96 Crore liters with a deficit of Crore 140.11 liters.

The observations and discussions with farmers also strongly support these calculations with water deficit for Rabi and summer crops, as farmers in Ambe-Dindori, Dakhamabe, Talegaon Dindori, Ashewadi, and Manori villages categorically shared that they face water shortage for 2 to 3 months during summer for irrigating crops, and even few of them are not able to take summer crops. There is water available for irrigating the crops throughout the year is reported by farmers in only Pimpalnare (where almost all farmer benefits from the Pimpalnare dam), and Khatwad (where the Waghad canal passes through the village area). The water balance is summarised in table 11.

Table 11: Water balance for the catchment with present average annual rainfall

The total amount of water available in the catchment for different uses (with annual average rainfall)			
Water available in form of soil moisture and groundwater recharge	Surface Storage from existing S&W work	Water getting imported outside the catchment	The total amount of water available (Cr.lit)
1201.37	**647.98**	**165.24**	**2014.58**
The water remained for crops in the catchment			
Water available in the village for different uses	Water required for Drinking and other purposes	Evaporation and Evapotranspiration	Total (Cr.lit)
2014.58	**50.29**	**372.05**	**1592.25**
Water balance after meeting water needs of Kharif crops			
The water remained for crops in the Catchment (-)	Water required for Kharif crops (=)	Water surplus after Kharif crops	Water-use indicator for Kharif season
1592.25	**1331.65**	**260.60**	**0.84**
Water balance after meeting crop water requirement of Rabi and Summer			
Water balance after meeting water needs of Kharif cry7ops (-)	Total Water required for crops in Rabi and Summer (=)	Water deficit for Rabi and Summer crops	Water-use indicator for Rabi season
260.60	**471.96**	**-140.11**	**1.54**

The water balance analysis of the catchment indicated that the catchment faces a deficit of 140.11 crore liters of water for different water needs, mainly during Rabi and summer seasons, highlighting the need to address this deficit by implementing the water resource development (supply-side) and management (demand-side and governance) measures in the catchment villages. The detailed water balance of the catchment is attached in annexures (annexure no. 1).

2.3.2 Catchment water balance for projected rainfall

Even, we tried to understand the water balance with climate change projections and increasing water demands in near future. With climate change implications, India is one of the largest and most important regions of high overall human vulnerability (Thow & Blois, 2008). In the last few years, we are witnessing the growing incidences of changing monsoon/precipitation behaviour in Maharashtra. The climate scenarios predict that after a good rainfall year, the gap of dry period of low or low rainfall years which is 2 to 3 years at present, may increase by 4 to 5 years. Keeping these scenarios in mind, we used the below scientific models to project the rainfall for the next 30 years for the catchment area.

2.3.1.1 Climate models: Global coupled Atmospheric-Ocean General Circulation Models (coupled GCMs) are the modeling tools traditionally used in theoretical investigations of climatic change mechanisms (Covey et al., 2003). By using GCMs, we can not only simulate the present-day and project future climatic changes under different scenarios but also separate natural climate variability from anthropogenic effects. Several improvements in the physics, numerical algorithms, and configurations are implemented in the IPCC AR5 models with a new set of scenarios called representative concentration pathways (RCPs) used in the AR5 simulations (Moss et al., 2010). The RCPs span a large range of stabilization, mitigation, and non-mitigation pathways.

2.3.1.2 Representative Concentration Pathways (RCPs): The GCMs simulations for the fifth assessment report (AR5) of the IPCC have recently become available (Taylor et al., 2012). The models have been produced taking into account the recently presented RCPs for four distinct scenarios such as RCP 2.6, RCP 4.5, RCP 6.0, and RCP 8.5. In light of these four scenarios, the climate projections for the future can be assessed from various models accessible under the CMIP5 venture. It has been established that the models of the CMIP5 data set have a higher spatial resolution and henceforth are relied upon to yield significantly more accurate results (Sperber et al., 2013). This study uses information from 2 suitable models for the Indian monsoon that participated in CMIP5. The resolution of model output is 0.25*0.25 degrees which is downscaled by the NEX-GDDP program of NASA. Models are chosen in light of the accessibility of suitable data for comparison and projection purposes. The respected data run the projection models is extracted from the NASA link: https://cds.nccs.nasa.gov/nex-gddp/. The result of the models is shared below.

2.3.1.3 Rainfall projections for the next 30 years: Applying the above models, rainfall is estimated for the next 30 years (2021 to 2050). As depicted in figure 29, the annual rainfall for the region has been erratic for this period, despite the increasing trend line. The highest annual rainfall is projected for the year 2043 (1817.84 mm) and the lowest rainfall is projected for the year 2033 (368.79 mm).

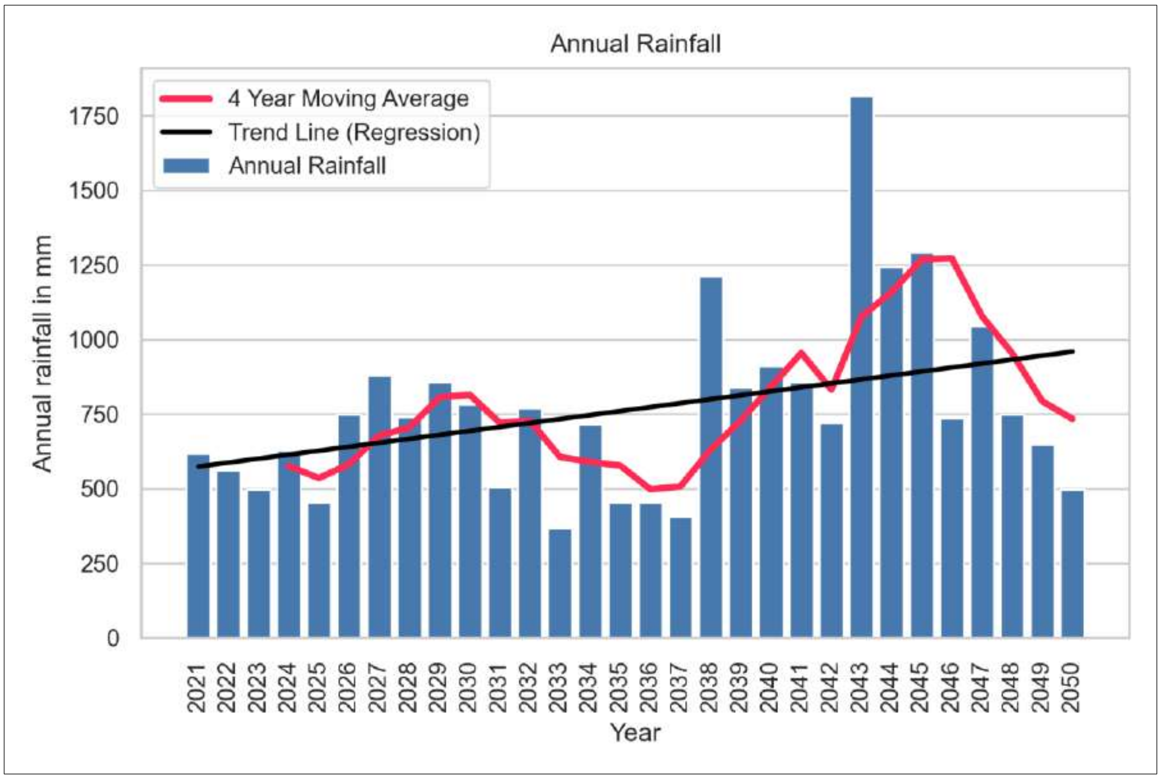

Figure 29: Projected annual rainfall for next 30 years

2.3.1.4: Excess and deficit rainfall years: Although the state considers the present annual rainfall for the district as 781 mm, the climate projection shows it will reduce a little bit to 767 mm for the next 30 years. As shown in Table 12, out of 30 years under consideration, 18 years have seen deficit rainfall and excess rainfall for 12 years (in comparison to annual rainfall). The data also clearly shows for the next 15 years (2021 to 2035) there will more rainfall deficit years whereas from 2036 to 2050, there will be excess rainfall years (above the annual average).

For the scenario building of the projected water balance of the selected catchment in the study, we built two scenarios for two years where the rainfall is projected the lowest till 2050 (Scenario 1 wherein 2025 rainfall is projected 452.53 mm, and scenario 2 for 2033 with rainfall 368.79 mm). Even, we considered the 10% increased water demands/requirements for the scenario building. The results for these projected deficit years are shown in table 12.

Table 12: Projected rainfall for next 30 years compared to average rainfall

Years	Annual Rainfall (mm)	Average Rainfall (mm)	Excess/Deficit	Years	Annual Rainfall (mm)	Average Rainfall (mm)	Excess/Deficit
2021	617.32		Deficit	**2036**	452.67		Deficit
2022	561.02		Deficit	**2037**	407.52		Deficit
2023	497.86		Deficit	**2038**	1211.27		Excess
2024	628.35		Deficit	**2039**	838.51		Excess
2025	452.54		Deficit	**2040**	911.65		Excess
2026	748.66		Deficit	**2041**	858.76		Excess
2027	880.16		Excess	**2042**	719.65		Deficit
2028	740.34	766.71	Deficit	**2043**	1817.84	766.71	Excess
2029	857.18		Excess	**2044**	1243.29		Excess
2030	781.93		Excess	**2045**	1291.81		Excess
2031	503.0		Deficit	**2046**	734.67		Deficit
2032	770.46		Excess	**2047**	1044.11		Excess
2033	368.79		Deficit	**2048**	747.48		Deficit
2034	716.28		Deficit	**2049**	646.97		Deficit
2035	453.09		Deficit	**2050**	497.95		Deficit

Table 13: Water balance for the catchment with projected lowest rainfall years

Scenario-1: The projected total amount of water available in the catchment for different uses (in 2025 with 452.53 mm rainfall)			
Water available in form of soil moisture and groundwater recharge	Surface Storage from existing S&W work	Water getting imported outside the catchment	The total amount of water available (Cr.lit)
696.10	**611.07**	**165.24**	**1472.41**
The water remained for crops in the catchment			
Water available in the village for different uses	Water required for Drinking and other purposes	Evaporation and Evapotranspiration	Total (Cr.lit)
1472.41	**55.31**	**372.05**	**1045.04**
Water balance after meeting water needs of Kharif crops			
The water remained for crops in the Catchment (-)	Water required for Kharif crops (=)	Water surplus after Kharif crops	Water-use indicator for Kharif season
1045.04	**1331.65**	**-281.61**	**1.27**
Water balance after meeting crop water requirement of Rabi and Summer			
Water balance after meeting water needs of Kharif crops (-)	Total Water required for crops in Rabi and Summer (=)	Water deficit for Rabi and Summer crops	Challenges in meetings demands for Rabi and Summer crops
-281-61	**471.71**	**687.32**	

Scenario-1: The projected total amount of water available in the catchment for different uses (in 2033 with 368.79 mm rainfall)			
Water available in form of soil moisture and groundwater recharge	Surface Storage from existing S&W work	Water getting imported outside the catchment	The total amount of water available (Cr.lit)
567.29	**405.35**	**165.24**	**1167.88**
The water remained for crops in the catchment			
Water available in the village for different uses	Water required for Drinking and other purposes	Evaporation and Evapotranspiration	Total (Cr.lit)
1167.88	**55.31**	**372.05**	**710.51**
Water balance after meeting water needs of Kharif crops			
The water remained for crops in the Catchment (-)	Water required for Kharif crops (=)	Water deficit after Kharif crops	Water-use indicator for Kharif season
710.51	**1331.65**	**621.14**	**1.87**
Water balance after meeting crop water requirement of Rabi and Summer			
Water balance after meeting water needs of Kharif crops (-)	Total Water required for crops in Rabi and Summer (=)	Water deficit for Rabi and Summer crops	No water available for Rabi and Summer crops
-621.14	**471.71**	**1021.85**	

As shown in table 13, scenario-1 with rainfall (for 2025 with rainfall 3462.53mm) predicts that for the Kharif season water will be available to meet the water demands but, farmers may face severe water scarcity during Rabi and summer seasons, resulting in crop losses or low production. However, scenario-2 (2033 with rainfall 368.79) is very alarming, in this scenario farmers may face difficulties and challenges even fulfilling the crop-water demands during the Kharif season, with very little or no possibility of growing crops in the Rabi and summer seasons.

The water balance in both scenarios (1 and 2) points out that, unless the water supply and demand-side management in the catchment villages are improved, the villagers, farmers, and industrial units may suffer from a severe water shortage for meeting their different water needs in near future. This analysis alerts planners and practitioners to seriously reflect on the future water balance projections and take the necessary precautionary actions.

2.4 Water balance of Godrej Plant

Along with preparing, the water balance of the catchment, the other important objective of the study was preparing the water balance for the Godrej-NGCARD unit in Ashewadi to the bottom of Ramshej fort. We used different data and information sources for calculating the water balance for the plant, we made a field visit to the different sections and units in the plant and several discussions with authorities and the field team of the plant. The structured checklist of the data requirements was prepared by us which was filled and shared by the plant authorities, this was further discussed and finalized.

For ensuring the water security of the plant, considering the projected needs in the future, the water balance is prepared. The water balance plan mainly covers the components of a) Water inflows/sources/ imports, b) Water consumption for different needs, c) Water quality and WASH status, d) Wastewater: sources, scale, disposal/reuse system, and e) proposed plan for water security of the plant (Table 14).

Photo 37: *Godrej Agrovet plant in Ashewadi at Dindori, Nashik*

Table 14: Water Balance and security plan for Godrej-NGCARD Plant

	Indicators	Data/Info
A	Water sources-The physical scope	
A1	Number of dug wells within plant fencing	No dug well in premises
A2	Number of bore wells within plant fencing	No borewell
A3	Number of farm ponds/storage tanks within plant fencing	1 Pond with 1Cr liters capacity
A4	Water import (by tankers or any kind of import) in last five years (average number)	5 Cr liter in 5 years from the nearby farmer (1 Crore per year for farm pond)
B	Water balance	
B1	Inflows (in Crore liters)	
B1.1	Annual water available from dug wells	No dugwell
B1.2	Annual water available from bore wells	Not bore well
B1.2	Annual water available from roof water harvesting/storing rainwater	No roof-water harvesting system in the plant
B1.3	Annual water available in farm/storage pond (and source of water)	60 lakh liters (out of 1 Cr capacity)
B1.4	Annual water getting exported by tankers or other means	No export
B2	Water Losses (in Crore liters)	No loss
B2.1	Water evaporation from farm/storage tanks	40 lakh liters
B2.2	Water losses in piped water supply/pipe network/other errors	No loss of water
B3	Consumption/Outflows (in liters)	
B3.1	Annual drinking and sanitation requirement of staff+workers+ all habitats in the company fencing (Total number of habitats)	15 lakh liter per year (NGCARD +R&R)
B3.2	Annual drinking and sanitation requirement of livestock/cows (drinking, washing, washing cow sheds, and others)	90 lakh liters in a year for cattle drinking and washing
B3.3	Annual water requirement of feed	10 Lakh ltr per year for feed making and processing

	Indicators	Data/Info
	making/processing for livestock	
B3.4	Annual water requirement for gardening, vehicle washing, etc.	12 lakhs per year (5000 liters per day for 8 months =12,00000 in a year)
B3.5	Please mention any other water requirement of the plant and the annual water quantity required	No
B3.6	Is the water quality from all water sources is good, if not what measures are being taken for water purification within the plant and at the source of water	Water quality is not good. Chlorination and RO for the filtration system get used in the plant.
B3.7	Changes in bulk water requirement in last five years in Crore liters (2017, 2018, 2019, 2020, 2021)	Water requirement of the plant increased a yearly basis
B3.8	Projected changes in bulk water requirement in next five years in Crore liters	1.5 Crore (50% more)
B3.9	Annual water-related costs on water import /maintenance of network etc.	= Rs. 7 lakh (0.07 paise/liter for 1 Crore liters)
C	Water discharge/waste management	
C1.1	Discharge points of wastewater in plant premises (please describe)	There is very low water discharge from the plant, if discharge then it is as per MPCB parameters only.
C1.2	The annual amount of wastewater getting generated the from the plant premises	7.30 lakh liters annually (2000 liter per day (cow-shed washing, washroom waste, and other uses)
C1.3	System of water wastewater disposal/ recycling/reuse in Crore liters	STP & ETP installed (Effluent treatment plant -ETP and Sewage treatment plant-STP). Recycled water gets used for the gardening purpose in the plant
C1.4	The annual amount of wastewater gets discharged directly into streams/land out of plant premise in Crore liters	No water gets discharged without treatment
C1.5	Incidences of wastewater getting discharged directly into streams/land out of plant premise in last 5 years	No incident to date

	Indicators	Data/Info
C1.6	Level/scale/incidences of pollution/contamination of water bodies or groundwater sources in the catchment from wastewater generated from the plant.	No
C2	Water Balance	Total annual water available from all sources = 1 Crore liters Total annual water consumption for all needs= 1.17 Crore (Cows and cowsheds+Drinking+ Gardening) Water balance=17 lakh deficit
D	Stakeholders and contribution to Water-Related Areas	
D1	The important villages and key people in villages who are supportive of plant or have goodwill towards plant as few activities are done by the plant under CSR.	Ashewadi, Tungaldara
D2	Any legal/socially imposed restriction/limitations faced by the plant authorities in making water available, water-use, and consumption.	No such incidence
D3	What type of contribution is made by the plant under CSR activities to conserve and promote Water-Related Areas (water conservation, maintenance of water bodies, catchment structures, groundwater recharge, beautification of water bodies, enhancing water services for social, cultural, livelihoods water needs in the catchment area/surrounding villages)? Please explain	-No such interventions. -The unit has done activities of distributing grains, grocery kits, C-19 masks, and soaps -Constructed ZP school toilets, a cooking room at Tungaldara, Library at ZP Jambutake school -Oxygen concentrator, masks, sanitizer, and gloves to Jambutake PHU
D4	What type of contribution is made by the plant under CSR activities to ensure WASH (Water and Sanitation and Health) services in villages such as overhead, tanks, public tap connections,	-No interventions on WASH

	Indicators	Data/Info
	Toilets, water purification plants/water ATMs for villagers (please explain in details).	
E	Proposed plan for addressing the deficit of 17 lakh liter (Water Security Plan)	
E1	Supply-side interventions- Creating additional water-storing potential	-Rainwater harvesting/Roof water harvesting systems for all buildings in the plant -Underground storage tanks -Reducing the rate of evaporation from farmpond by 50%, will increase the water availability by 20 lack liters annually. -Deepening and widening existing well within plant premise
E2	Demand-side interventions- improving existing water use efficiency	Need further investigation into this on water use efficiency of existing technologies/machinery/water-use practices, alternatives or improvements in this.

Photo 38: *Godrej Plant with the main water source (farmpond)*

Chapter 3. Stakeholders mapping and shared water challenges

Exploring the possibilities presented in the earlier chapter, to plan and implement the recommendation requires multiple and relevant stakeholders to come together and offer their strengths, expertise, and resources. This chapter presents the overall stakeholder mapping process adopted, the relevant stakeholders identified, their linkages and associations with each other, and the ranking of these stakeholders on basis of the strengths they can bring and for achieving the objective of sustainable and judicious use of water and land management in the catchment.

3.1 Stakeholder mapping process

Change initiating any change in the system, particularly with the complex and dynamic nature of natural resources, like water and agriculture, superimposed with diverse socio-economic and cultural-political features, require a multistakeholder approach. Visualizing the change process to be initiated in the catchment, surrounding Godrej Plant, for development and management of water resources (supply and demand side as well as governance), agriculture development focusing different farmers groups, and livelihood of people, we have designed and conducted the stakeholder mapping process. The Assumption behind the stakeholder mapping process is that, as this study is supported by different partners, involving more government, non-government, and villages level institutions, along with other relevant stakeholders, together have to make the roadmap for the change and explore the level of influence (the support ad strengths) these stakeholders can bring to achieve initiative and achieve the change. The overall stakeholder engagement was conducted by following important steps.

3.1.1 Stakeholder Identification

In this initial review of secondary literature and analyzing data, as well as based on discussions with Godrej Plant officials, key-Villagers and local NGOs, and a few government officials during the initial visit, the broad categories of stakeholder and stakeholding groups were identified. Keeping in mind these broad categories, the respondents were selected and interview tools and checklists were developed for conducting focused group discussions with key participants. The list of identified stakeholding groups is presented below

i) Village institutions: Gram panchayats, Water User Associations (WUAs), Village Water Supply and Sanitation Committees (VWSSC), Men and Women Self Help Group (SHGs), Rojgar Sevak under Mahatma Gandhi Employment Guarantee Scheme

ii) Government Departments and Officials: Taluka Agriculture officer in Dindori and his team (Mandal Krushi Adhikari and Agriculture assistants), Gramsevaks, Groundwater Survey, and Development Authority, Central Groundwater Board (CGWB), UMED Team of State Livelihood Mission for entrepreneurship and livelihood development

iii) NGOs: Sampada Trust working in the catchment villages

iv) Donor Agencies and knowledge partners: Godrej Pvt.Ltd, Global Agribusiness Action on Equitable Livelihoods (GAA-EL), Alliance for Water Stewardship (AWS), Watershed Organization Trust, and other CSRs working in the catchment.

3.1.2 Stakeholder Analysis

During the FGDs and interviews, we tried to understand the perspectives and interests of stakeholders and stakeholding groups. The specific focus was given to understand how they see their role and responsibilities in the larger picture with inter-linkages of different issues, for example, the agriculture department has no direct connection with water quality but we explore with them how agriculture practices of intensive chemical and fertilizers are affecting the water sources and where they find their role in addressing this. Thus we focused to understand their possible roles and contribution beyond the assigned roles of each actor and stakeholder group. This analysis is also strengthened with the literature review of relevant actors related to the catchment development.

3.2.3 Stakeholder Mapping

Stakeholder mapping is a very useful process for visualizing relationships of each actor and stake-holding group with each other, and how they jointly constitute to achieve the larger goal. Considering the proposed set of activities for the catchment development, with the adoption of water stewardship, agriculture, and livelihood promotion, the stakeholder map is shown in figure 30.

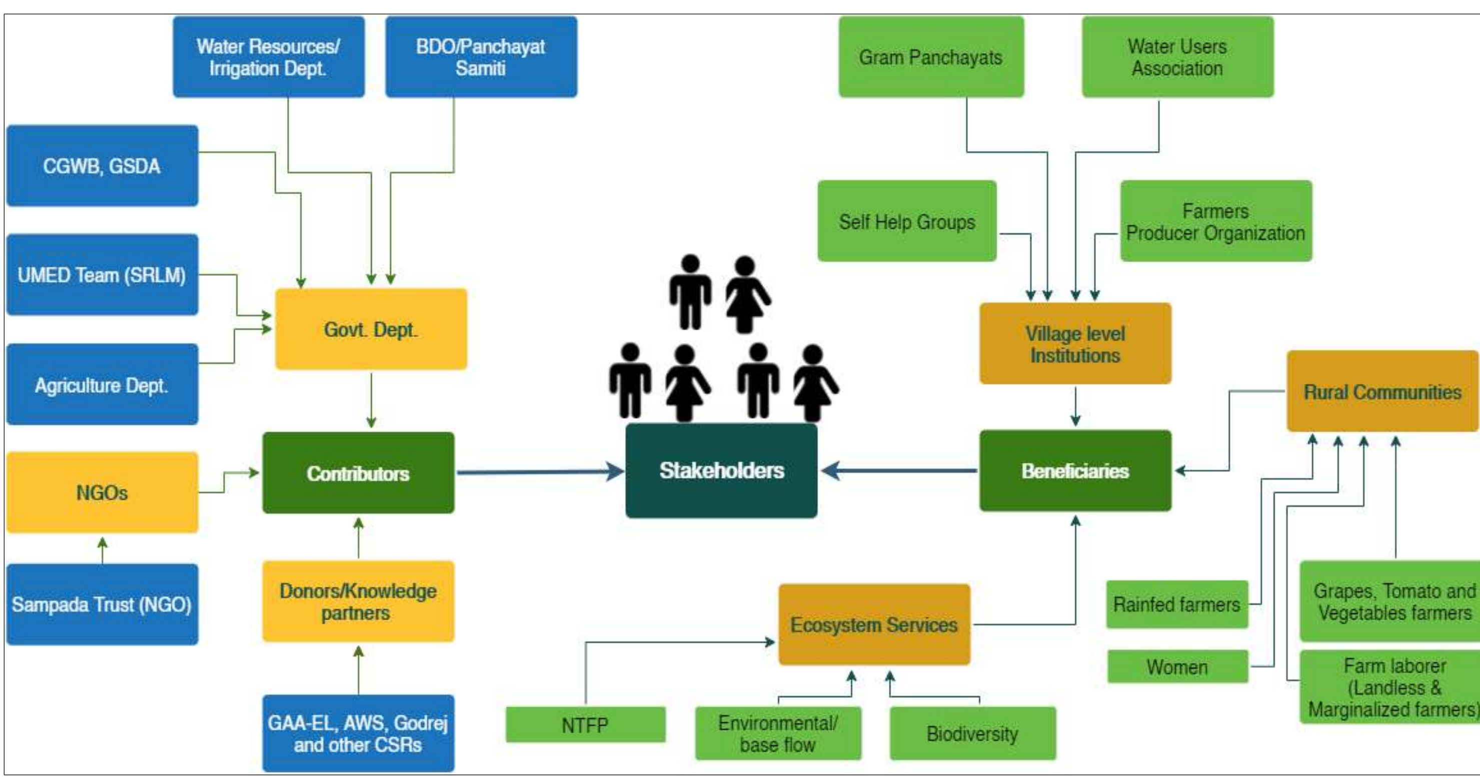

Figure 30: *Description of stakeholders mapping*

3.1.4 Level of Influence of Stakeholders

Ranking of identified stakeholders or determining the level of influence of stakeholders and stake-holding groups is essential to prepare a clear roadmap for changing the systems. For this, we need to clearly see what strengths and expertise each stakeholding groups bring for achieving the set common objectives. For the catchment development, we have ranked the stakeholding groups on basis of financial resources and knowledge they can bring for implementing the recommendation discussed in the earlier chapter, and, ensuring the equity, participation, and sustainability in the outcome of these interventions. The detailed stakeholder ranking is summarized in table 15. In the table points for level of ranking are marked in 5 points (+ as lowest, and +++++ as highest).

Photo 39: *Women participants in discussion in Pimpalnare village*

Table 15: Level of Influence of Stake-holding Groups

Levels of stakeholders and Agencies	Agencies and stakeholders	Fund/ Financial flow	Surface and Groundwater development & Management	Soil and crops management and marketing	Livelihoods	Knowledge and Capacity building	Sustainability of interventions	Participation, Equity, and Environmental Concerns
Government and Non-government	CSRs-working in the cluster (Godrej and others)	+++++				++++		
	GAA-EL, AWS	+++++				++++		
	WOTR		+++++	+++++	+++	++++	+++	+++++
	Sampada Trust, Dindori	+	+++	+++++	+++++	+++++	++	++++
	Agriculture department-TAO office	+++	++	+++++	++	++++	+	+
	GSDA- Sr. Geologist, Nashik		+++			+++		
	Central Groundwater Board		++			++		
	Water Resource Department-irrigation department	+++	+++			+		+
	Block Development Officer, Dindori	++	+++	+	+++			
	Mandal Krishi Adhikari	++		++++		+++	+	++
	Agriculture Assistant			++++		++++	+	++
	Gram Sevaks				+++			
	Rojagar Sevak-MGNERGA		++++	+	+++			
	Umed-MSRLM	++			++++	++		+++
Village institutions	Gram panchayat	+	+	+	++		+++++	++++
	Water Users Association	+	+++	++++			+++++	+++++
	Men and Women SHGs				+++++		+++	+++
Govt schemes and Programs	Jal Jeevan Mission	++	+					++
	IWMP	+++	+++	++	+++		++	+++
	MGNREGA	+++	+++	++	+++		++	+++
	NRHM	++	++	+++			+	+
	Atal Bhujal Yojana	+	+++			++++	+++	++
Govt Policies and laws	Maharashtra GW Act 2009		+++			++		+++
	MMISF-2005,					+++++		++++
	State Water Policy		++			+++	++	++
	Maharashtra state agriculture export policy 2019			+++	+		++	++
	MSAPCC			+			+++	+++

Chapter 4. Shared water challenges and proposed Water Stewardship Plan

Based on the analysis in earlier chapters and discussions with multiple stakeholders groups, this chapter prescribes the necessary interventions to water, soil, land, agriculture challenges discussed. In the first section, the chapters point out the different shared water challenges by catchment villages as well as Godrej Plant, and the second section present the detailed set of proposed actions required at various levels to address the challenges towards and achieving water security at the catchment level, focusing principles of sustainability, equity, and participation with the larger framework of water stewardship. Thus, this chapter provides the specific prescription to the problem diagnosed.

4.1 Shared water challenges

This section presents the discussion on shared challenges in catchment villages, by elaborating the different dimensions and aspects of water and agriculture-related sectors.

4.1.1 Water shortage for drinking and domestic water, poor water quality, and WASH services

The analysis clearly indicates that most villages are facing water scarcity and quality issues for drinking water in the catchment. Apart from the Pimpalnare villages which have a perennial source for drinking water well (Pimpalnare dam) and water purification system (water ATM installed in the village), no village and its hamlet receive drinking water with good quality throughout the year by public amenities (Grampanchyat). Each of these villages faces water scarcity at least for 2 to 3 months during the summer. As the settlement in many villages are scattered and many families settled in farms, few major hamlets in various villages face major challenges in availability and quality as the water ATMs are installed in major settlements or Gaothan areas. Therefore, few families purchase water cans of purified water from private suppliers or access water from private water sources. Here important to note that as better-off farmers are shifted to farms have built good houses and water facilities, most vulnerable groups live in villages and face water difficulties to access adequate water with good quality, for example, the Khatwad village has the most irrigated area one of the prosperous villages but much better of farmers shifted in their farm and villages remained in the village settlement (mainly SC/ST households) have no any water purification system in the village. However, when it comes to the Godrej plant for drinking water security, adequate measures have been observed for ensuring the water quality.

4.1.2 Water shortage for productive and irrigation water use

Water shortage for productive and irrigation use has a common challenge for the villages in the catchment as well as Godrej Plant. We have seen in an earlier chapter that water balance at catchment level has a water deficit of 140 crore liters as well Godrej NGCARD plant has faced a deficit of 17 lakh liters annually. Only the two villages Pimpalnare and Khatwad have adequate water throughout the year as Pimpalnare has a dam, well managed by WUAs, and Khatwad villages fulfil their water requirements through the canal and the farm pond. The rest of the villages shared water scarcity for Rabi crops and summer crops. The farmers who afford for investing in constructing farm ponds (mainly grape and tomato cultivating farmers) or availing benefits of government schemes are in advantageous positions of irrigation benefits, but other farmers face water scarcity for their crops. Although almost irrigated farmers use micro-irrigation technologies for irrigating crops, the area under irrigation is huge. It has been seen that there are a good number of commercial poultry farms in the catchment, however, they manage water needs from local sources, and if required import the water by private tankers.

4.1.3 Unsustainable agriculture practices and crop marketing

Unsustainable agriculture practices have been seen across all the villages in the catchment. Intensive cultivation (without fallowing period for soil), heavy use of chemicals and fertilizers, application of plastic paper on the huge area for mulching for tomatoes and other vegetables are the measure practices that are affecting the primary fertility of the soil. Even, farmers are also experiencing these problems but for increasing the production and ore income, they are ignoring these practices and have no boost for organic practices in agriculture. Farmers also reported the increasing incidences of crop loss due to weather events, mainly hailstorms, heavy rainfall, and winds and storms and they are finding it helpless to deal with. Few farmers reported that they are receiving a message about weather predictions from KISAN portals and others, but they are not finding these more appropriate and specific to local conditions. On the crop marketing front, as shared earlier there is a well-established system for marketing of grape crop in the catchment, however, for tomatoes, which is the major crop in the catchment, there is huge potential to strengthen the marketing system through FPOs, processing units and constructing warehouses.

4.1.4 Poor Water Governance

The major water management institutions in the catchment villages are the WUAs. Almost in each village, there are WUAs, however, apart from Pimpalnare village, the WUAs are poorly functioning. Even, when it comes to water sharing and equity, Pimpalanare villagers have established a monopoly on it, downstream villages, Dakhambe and Manori, or nearby Talegaon Dindori villages are not allowed to take irrigation benefits from the dam. Even, earlier there was a network of the proper canal system and minors from the dam, and farmers from Talegaon shared that long back they received an irrigation rotation once from the dam to them. But as shared by farmers from Talegaon-Dindori, as the key persons and local politicians in Pimpalnare are very powerful, they received the permission from water resource department for reserving the dam used for only Pimpalnare, and thus canal network is dysfunctional and Pimpalnare villagers are directly lifting water from dams by pumps through WUAs.

Photo 40: *Dysfunctional Canal from the Pimpalnare dam* ***Photo 41:*** *Dysfunctional dam in Ambe Dindori village*

As discussed most WUAs are not very active, women have very insignificant representation in them, and hardly any meetings were organized of these WUAs. Very poor management of local water resources in the catchment is observed. More focus and interest in villagers and key people are seen to import more and more water from outside villages or outside the catchment, ignoring the development and strengthening local water resources. Groundwater, which is an important resource, is overlooked as more race is for importing water and storing it in farm ponds.

On demand-side management, no specific efforts are seen to protect drinking water sources, local rules regarding crop practices and water-use, even in no village we have listened about the water budgeting practices and other management tools. The main challenge observed is to mobilize and sensitize the villagers for collective work on responsible water management, as many farmers are settled at their farms and most of them have the mindset for protecting water sources for their individual water use, rather than coming together with an understanding of water as common property, therefore promoting the culture of water stewardship in the catchment is the challenging, but necessary task.

4.2 Proposed Water Stewardship plan: Solutions and Opportunities

In this important section, we present the prescription to the identified challenges and propose the set intentions to achieve the inclusive, sustainable, efficient use of the natural resource with the broader framework of water stewardship in the catchment (catchment villages as well as Godrej Plant). These opportunities and recommendations to address the challenges are mainly categorized for water resource development (supply and demand, and governance measures for surface as well as groundwater), agriculture practices and marketing (reflecting livelihoods), as well as water for sanitation and health (WASH).

4.2.1 Recommendations for supply-side water management

As we have found the water deficit for different needs in the catchment as well as at the Godrej plant, this subsection provides the prescription to meet the current deficit as well as future projections.

4.2.1.1 Repair and maintenance of existing soil and water conservation structures

There is huge potential in repairing the existing soil and water harvesting measures in the catchment which increases the sustainable amount of water harvesting potential in the villages.

Most checkdams, percolation tanks, and earthen bunds are silted and few are broken or have major leakages, this significantly lowered the water harvesting capacity of the structure in comparison to the total water harvesting potential created while the construction.

With the repair of existing checkdams, percolation tanks, and irrigation dams, as shown in table 16 additional water 143. 68 crore liters of can be harvested in the catchment. Even, technically this will not be the only potential water harvested that will be created, but as there is good rainfall in the catchment these structures will fill 2 times or three times during the monsoon and even add to the groundwater resource through percolation. Thus, there are huge opportunities and potential in repairing the broken, damaged, leaked water harvesting structures.

Table 16: Additional water harvesting potential in irrigation dams

Type of structure	No. of defunct structures	Details of problem	Additional water harvesting can be created in Crore Liters
Irrigation dams	3	Silt deposited in heavy amount	125.95
Percolation tanks/earthen bunds	18	Silted, sidewall, and main wall leakage/broken	13.59
Cement Check dams	18	Silt deposited, Wall damaged/leakage	3.84
Total			**143.68**

The structure-wise details of irrigation dams, percolation tanks, and cement dams on details of problems and Additional water harvesting can be created is presented in annexures No 2.

Along with this, in the catchment total forest area is 727 ha. However, the satellite image analysis shows that only on 250 ha. There is dense tree cover/good number of trees, this indicates that there is still good potential for plantation/afforestation in the catchment. It has been also observed that long back, on very few areas around the Ramshej fort, CCTs were done but now they are filled and they can be reviewed and deepened.

4.2.1.2 Constructing new Soil and Water Conservation structures

There is limited scope for constructing new big water harvesting structures like percolation tanks and earthen bunds, but in the upper catchment, there are two potential sites (in Ashewadi and Gavalwadi) for constructing checkdams. Even Ramshej fort is at the highest elevation in the catchment, there is enough scope for digging Water Absorption trenches

(WAT). To reduce the runoff in the upper catchment, stone bunds and a few gabions structures can be also constructed in primary and secondary streams in Manori, Gavalwadi, and Ashewadi village areas.

Nala/stream deepening and widening is also found feasible in a few locations at Talegaon Dindori, Manori, Ashewadi, Dakhambe, Ambe-Dindori, mainly in identified groundwater recharge areas. Considering the increasing gap in two good rainfall years, this strategy will be more useful to store more water and percolate it, however, this work needs to be followed strict guidelines and has to be done under the close supervision of technical experts.

4.2.1.3 Artificial Groundwater recharge

The analysis and all available secondary literature show that the aquifers in the catchment area are very poor recharge potential and yield, however, with the advanced techniques and technologies, the aquifers in the catchment can be certainly strengthened as all evidence show that groundwater will be the crucial source for life and livelihoods in the coming years in the context of climate change. As it is well researched that groundwater recharge is a natural and artificial process through which aquifers of the region get water recharged. Among artificial recharge techniques, Managed Aquifer Recharge (MAR) is a very prominent and promising technique intentionally for strengthening the aquifers and increasing groundwater stock. MAR is found to be a cost-effective technique that has resolved several water-stressed problems across the globe.

Groundwater Surveys and Development Agency (GSDA) has also done rigorous work across Maharashtra in the sector of groundwater development and management by generating village-wise maps for groundwater recharge potential, with drainage and lineament layers. We have done an extensive exercise to connect these village maps for catchment villages to see the larger and holistic picture of groundwater recharge and discharge zones, with connections and linkages of catchment level geohydrology. The map we generated with the GSDA data sources, (Figure 31), indicates the high priority zones are falling along the drainage, which clearly imparts the idea about the source of water and a possible passage to recharge the neighboring aquifer. Moderate priority zone falling next to the high priority zone which is immediate to the drainage and the possibility of recharge is intermediate which requires close ground surveys before any intervention. The upstream side of the catchment which is mainly ridgelines are falling in a low priority zone, which is obvious because the runoff will be maximum and the infiltration would be on the minimum side. However, some drainage lines intercept the lineaments, found to be the most suitable site for implementing MAR, where the drainage line will act as a source of water and lineament will provide the passage for recharging the aquifer, hence, these regions are recommended for the below interventions.

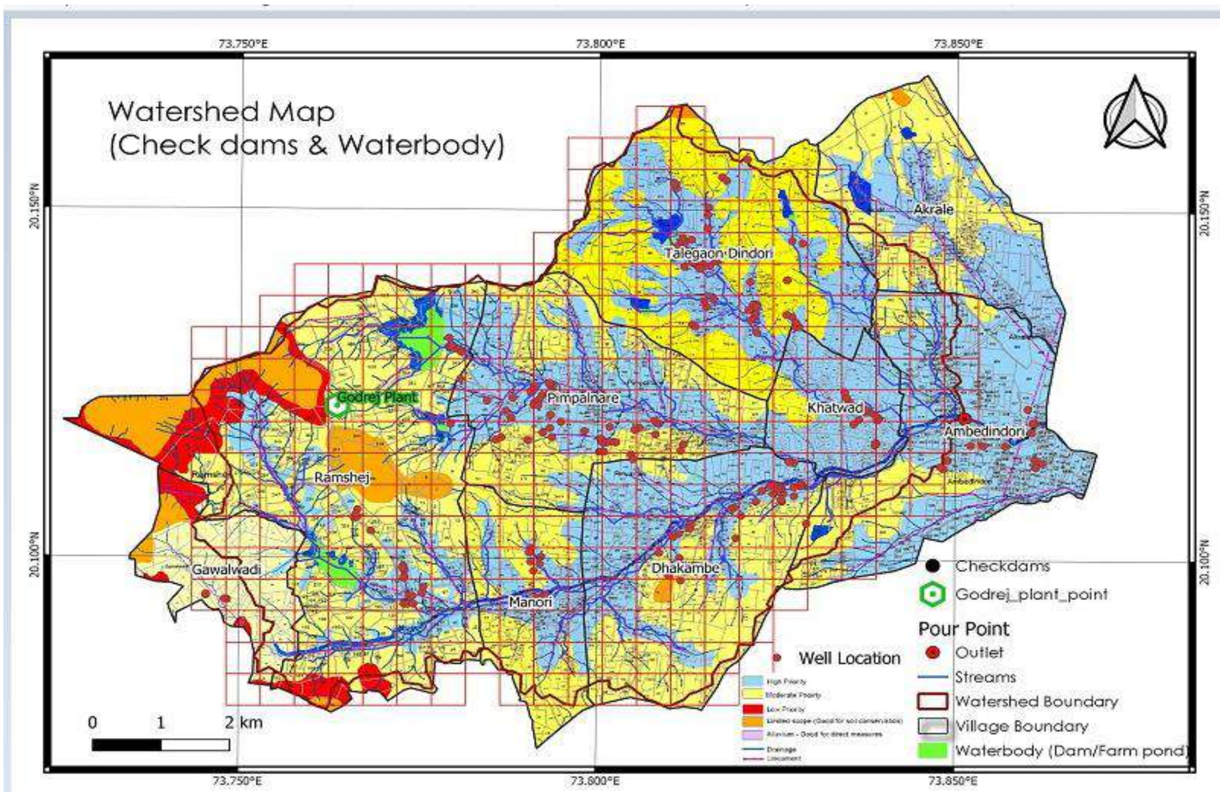

Figure 31: Representation of artificial recharge site in the area of study (Data Source: GSDA)

a) **Recharge Shafts:** At the appropriate places in the recharge zone in the catchment, mainly in the water storage area of check dams and percolation tanks as well in the stream, recharge shafts can be constructed, this technique is also well known as injection boreholes. These shafts are found very useful for recharging the aquifers if they are constructed at the right place, the geological analysis and different maps prepared in this study will be immensely useful for this purpose. GSDA has extensively constructed such recharge shafts nearby public drinking water well in many villages to strengthen the aquifers surrounding the wells. This is also a low-cost intensive treatment and results in a good amount of benefits.

b) **Hydro-fracturing:** In the groundwater recharge area, artificial fractures can be made for more recharge by using the hydro-fracturing technique. This needs adequate expertise and consultations with scientific experts, but its applications have shown significant benefits in basaltic rock/Deccan trap aquifer for creating more groundwater recharge potential and increasing aquifer stocks. This technique will be certainly useful and ideal in catchment villages, mainly in the upper part of the catchment.

c) **Extensive Soil and water harvesting development in the upper part of the catchment:** As the rainfall of the area is good (annual average 781 mm) and there are all chances of the increased and variable runoff by changing the runoff and recharge cycle in coming years, upper catchment area must get extensively implemented with soil and water conservation treatment for lowering the runoff by giving more time for a recharge. Therefore, CCTs, stone bunds, gabion structure, and

Nala bunds, unlined small farm ponds for percolation purposes, with increasing the vegetation will be very useful interventions in the upper catchment. These interventions will be also useful for lowering the soil erosion and sedimentation in percolation tanks and checkdams throughout the catchment.

d) **Regulating the stone mining in the catchment:** In the upper part of the catchment, mainly Ashewadi and Manori villages, mining and stone crushing units in the catchment are increasing and creating the threat for drinking water sources. The rainwater runoff gets arrested and in the deep pits of stone mining, and directly gets percolated in the aquifer, without any natural filtration and affecting the groundwater quality. Care has to be taken at the administrative level that these sites do not affect the groundwater. The possible solution may be to take a measure that runoff from the surrounding area gets well diverted and does not add to these mining pits.

4.2.1.4 Recommendations for water security of Godrej-NGCARD Plant

As the deficit of 17 lakh liters of annual water deficit is observed at Godrej NGCARD plant at Ashewadi, the following specific measures will be the practical and easy solutions to meet the deficit with additional water for future projected needs.

a) The most practical and easy solution is reducing the rate of evaporation from farmpond in the premise which has a capacity of 1 crore liters and is the most important source of water for the plant. With all estimation, around 35 to 40 crore liters of water get annually evaporated from the tank. We recommend that to take measures for reducing the evaporation of tank by 50%, this will increase the water availability by 20 lakh liters annually. The system of floating balls, covering the pond, applying bio-chemicals, or other easy solutions (to be covered by wasted plastic water bottles) can be tried which with less cost will increase the assured water availability within the premise. Additionally, this intervention at the plant site in the farmpond can be a demo for other farmpond owning farmers to learn from and replicate this in their ponds.

b) Rainwater harvesting/Roof water harvesting systems for all buildings in the plant will certainly increase the water potential, the network of pipes can be set up to divert and store this water in farmpond or dug well in the premise.

c) As the more surface area for additional storage tanks is limited, underground water storage tanks can be constructed, or existing dug well can be deepened and widened to store more water.

4.2.2 Recommendations for demand-side water management

Demand-side management has mixed responses by farmers in the catchment villages. As the farmers in the catchment area are well advanced and practicing different technologies in cultivation, they are using micro-irrigation techniques very extensively. Hardly farmers practice flood irrigation, and in most villages, 100% of farmers have adopted this water-saving technology. As they have invested in farm ponds heavily, they also understand the economic value of water, therefore they use it more efficiently. However, there are following concerns and which are very necessary to take action.

a) As discussed earlier, to the excessive use of chemicals and fertilizers as well intensive irrigation/cultivation, many farmers reported that soil quality in the catchment is speedily deteriorating. The poor soil quality also affects its soil holding capacity by soil moisture or irrigation, requiring frequent irrigation. Therefore, practices of organic farming and sustainable land management practices (such as vermicomposting, organic mulching, organic formulations, etc., WOTR has developed a package of practices on organic farming with an experience of years) needs to be strongly promoted. The extensive demos on these practices in the catchment villages will motivate other farmers to learn from them and adopt these practices.

b) The approach and tool of Water budgeting practices in these villages were never tried earlier. Across the different regions in India, this tool proved very useful for building the capacity of villagers on building understanding on managing the water needs within availability as well as protecting and ensuring the drinking water availability for all in the village throughout the years. Of course, this tool has to be promoted with a water stewardship approach which is discussed in the next section on governance.

4.2.3 Recommendations for improving water governance in catchment villages

The major challenges, as discussed, for water management are the mindset of looking at water resources as private property and therefore taking all efforts to manage water at the individual level by farmers, by ignoring its common property nature and poor collective actions at the village level. Therefore promotion of the water stewardship approach is necessary for catchment villages to change the mindset of people and make them realize that water resources need to be managed collectively, ensuring its judicious, sustainable, and more efficient use. WOTR has done extensive work in designing and promoting this approach and implementing this approach in more than 100 villages in Maharashtra. The approach brings different actors and stakeholders together and builds the capacities through the stakeholder engagement process to make these stakeholders realize their rights and responsibilities. The water stewardship approach, which is tested and proved its usefulness, is missing in the program. Here, water users are not seen as passive beneficiaries or culprits for groundwater depletion, but if their skills and capacities are developed with behavioral change, they are seen as good water managers. By building a cadre of water stewards in the villages, water stewardship plans, including the water budgeting process, is an important component of the water stewardship approach. WOTR has done extensive work promoting this approach (D'Souza, Kale, & Pinjan, 2019), however, we understand certain additions and modifications have to be don for making this approach relevant to the catchment village, for example, WUAs formed in these villages have strengthened substantially with extensive capacity building for making them more participatory, inclusive, and effective. Thus, promotion of the water stewardship approach will be challenging in the catchment villages, but certainly will be the game-changer to improve the level of water governance, and make people more responsive.

Banganga River originates from Ashewadi village in the upper part of the catchment and flows through the most of catchment villages. The river is the important source of water for drinking and irrigation purposes for many villages in the catchments as well as a vital source of water for livestock, wildlife, and cultural/religious practices in the area, having the importance of continued environmental flows and biodiversity. The formation of a river management and protection committee for Banganga and strengthening it will be a very important initiative to manage the water at a small river basin level where the upper basin of this river and the delineated catchment match. This can bring many innovations in the proposed catchment development/waters stewardship plan.

4.2.4 Recommendations for improving agriculture and soil management

As it has been observed and rightly reported by farmers and NGO persons working in the catchment, deteriorating soil health is a crucial aspect. As reported by NGO person, they have found increasing sodium content in the soil in many plots. Farmers also shared that for the crops like grapes, tomatoes, and other vegetables the frequency of spraying chemicals is very high, almost thrice a day they spray on these crops, and even the use of chemical fertilizers is at an alarming level. These practices have many implications, mainly deteriorating soil, polluting the water sources, increased input cost of farmers, and thus, the overall sustainability of agriculture, life, and environment is threatened. To address these challenges, we are following a set of actions.

a) **Adoption of Climate Resilient Agriculture (CRA) practices:** Under the CRA practice, a different set of activities are proposed WOTR is promoting CRA practices to build the farmers' adaptive capacities to deal with changing climate. Better soil health practices are at the centre of this approach, which involves organic farming focusing on organic manures and organic formulations for spraying on crops. This also covers the different crop and water management practices, as crop rotations, mix crops, etc. However, as income from agriculture is the main motivation for farmers, CRA practices also ensure sustainable incomes for farmers.

b) **Local specific Crop advisories:** As part of CRA, a system of local specific and crop-specific weather advisories through mobile SMS services will help farmers to take necessary preventive measures to reduce crop loss. For this purpose, in each village, an automatic weather station has to be set and linked to the appropriate system. As the grapes and vegetables are more climate-sensitive, such local specific advisories will certainly result useful to farmers to protect their crops and reduce losses, in the wake of changing weather and monsoon pattern.

c) **Regulation on the use of plastic mulching paper:** The use of plastic mulching paper for tomato and other vegetables is huge in the catchment villages, for example as reported by farmers, in Manori village 300 farmers, and in Pimpalnare 587 farmers are annually using plastic paper for mulching, along with around 50% farmers in the remaining villages in the catchment.

   According to the officials of the block agriculture office, extensive uses of low-quality plastic mulching paper is giving rise to waterlogging, creating barriers for seepage, and affecting the soil content, because the low-quality paper is not degrading soon. As the low-quality non-ISI paper is comparatively less costly, most farmers are preferring this to purchase.

Therefore, awareness generation in farmers regarding sustainable farming practices has to be done pointing out the adverse impacts of low-cost mulching paper. Even there should be regulations by state and agencies to ban on production and sale of non-ISI plastic paper for mulching purposes.

4.2.5 Recommendations for improving the crop marketing system

As discussed earlier, all villages are close to the Nashik–Dindori highway, and easy access to Nashik and Dindori cities as wells as cities in nearby Gujarat state. Therefore have huge potential for exporting the farm produces, mainly tomatoes and vegetables. For Grapes system of trading is well set in the catchment villages and Anker Farms, a leading FPO in Dindori is active in purchasing and exporting grapes. However, for more profitable marketing of tomatoes and other vegetables, small FPOs in catchment villages can be promoted so that they directly export their crops to markets, without traders. These small FPOs can be incentivized for constructing storage and warehouses so that they can store farm produces for 2 to 3 days if the market rates are not favourable.

In table 17, we summarise the synthesis of the above-discussed risks and challenges, the recommended interventions, and strategies for addressing them in with expected and planned outcomes in the timeframe.

Table 17: Summary of the water stewardship /catchment development plan

Risks & Shared Water Challenges	Proposed Activities /interventions	Important stakeholders and their roles	Required Timescale	Potential outcome
Water shortage for drinking and domestic water, poor quality of water, and WASH services	Water RO plant/purification units in a few required hamlets and villages, strengthening of drinking water sources (dug wells and borewells) by recharge shafts, and Nala deepening.	Rural communities and village institutions will benefit and contribute their share where major cost has to come from donors	6 months	Drinking water security, ensuring the availability and the quality
Water shortage for commercial, perennial, and protective irrigation for crops	Repair (desiltation and repair of leakages and broken walls) of existing checkdams, percolation tanks, and irrigation dams	Beneficiary farmers will contribute their share, and the remaining share come from donors and agriculture and water resource departments (convergence)	12 months	Increased water availability in existing structures for different uses, Increased groundwater, resilience to deal with droughts and floods, development, regeneration of catchment/watershed, increased water availability, development of local water resources, balanced ecosystem
	Soil and water harvesting (watershed development) in the upper part of the catchment (forestation, constructing new soil and water conservation structures-checkdams, WATs, CCTs, and Nala deepening	Required funding has to come from donors and government departments where village institutions take responsibility for protection and sustainability	24 months	
	Artificial Groundwater recharge-Recharge Shafts and Hydro-fracturing in the groundwater recharge zone	In consultation with GSDA and CGWB, funding from donors and GSDA if possible		

Risks & Shared Water Challenges	Proposed Activities /interventions	Important stakeholders and their roles	Required Timescale	Potential outcome
	Reducing the rate of evaporation of water stored in farmpond in the Godrej Agrovet premise, roof water harvesting	In consultation with WOTR with fund support from Godrej Agrovet	6 months	Water security of Godrej-NGCARD Plant considering future water projections
Unsustainable agriculture practices and crop marketing, speedily deteriorating and poor soil quality, extensive use of chemical fertilizers, plastic mulching, and increased input cost of farmers (Overall sustainability of agriculture and environment threatened)	Adoption of Climate Resilient Agriculture (CRA) practices, better soil health practices, organic manures and organic formulations for spraying on crops, crop, and water management practices, crop rotations, mix crops, etc., multilayer farming for nutritional security/household level consumption.	Irrigated farmers (horticulture and vegetable cultivators) will benefit from this with funding support and guidance from donor agencies, the Agriculture Department, and WOTR or project implementing NGO	36 months	Increased soil carbon, water holding capacity of the soil, reduction in input cost of farmers in agriculture, increased resilience of farmers in crop practices and income, increased nutritional food consumptions increased alternative livelihood (production of vermi-composting and organic formulations)
Increasing incidences of crop losses in the wake of changing weather and monsoon pattern, volatile markets, and resultant losses and risks in benefits and income.	System of local specific and crop-specific weather advisories through mobile SMS services to farmers by the installation of automatic weather stations, farmers filed schools	Donors, the Agriculture Department, WOTR, Indian Meteorological Department, and village institutions work closely to install the weather stations and establish a system of sending the crop advisories to farmers	12 months	Farmers (grape and vegetable cultivators) review crop advisories and amount of crop losses is decreased and production is increased

Risks & Shared Water Challenges	Proposed Activities /interventions	Important stakeholders and their roles	Required Timescale	Potential outcome
	Formation and promotion of Farmer Producers Organizations (FPOs) in catchment villages so that they directly export their crops to markets, without middle persons/traders. These FPOs to be incentivized for constructing storage and warehouses for farm produces, women SHGs to be aligned in FPO activities/services.	Donors, the Agriculture Department, WOTR, and village institutions closely work with NABARD and Agricultural Technology Management Agency (ATMA).	36 months	Sharing the risks and benefits by farmers in collective marketing, increased and sustainable income to farmers from crop produces, livelihoods to rural youths and women in FPO activities
Poor water governance and collective actions on water management, the mindset of looking at water resources as private property, need to focus on demand-side management, least interest in local and groundwater resource management	Promotion of water stewardship activities, water budgeting practices, institutional and capacity building, stakeholder engagement, water literacy. Formation and strengthening of Banganga river management and protection committee, and activities for river development and management Capacity building and strengthening of existing Sanitation and Water Supply Committees and Water Users Associations Promotion of behavioural change communication practices and a cadre of water stewards in catchment villages.	Implementing agency (WOTR), with donor support, will closely work with village institutions and communities, with coordination, support, and guidance of the water resource department, agriculture department, CGWB, and GSDA.	36 months	Collective efforts of water management and in the catchment and efforts sustainable river management, water budgeting practices get followed in catchment villages, and teams of cable water stewards in the villages for promoting and implementing the better water management practices.

4.3. Summary and ways forward

The delineated catchment in the area of Godrej NGCARD plant at Ashewadi-Ramshej area, consisting of 9 villages with an area of 6688 ha. is characterized by modern farming and grape cultivation. Tomato and different vegetables crops are also important income sources for farmers. Irrigation dams, canal water from the Waghad dam, percolation tanks, checkdams, and farm ponds are important water sources for irrigation in the catchment villages. Although groundwater resource has limited availability in the catchment village due to basaltic geological formations, several wells in this village are also significant and farmers are using it mainly for water storage as the groundwater yield is very low.

Water scarcity in summer months for drinking as well as irrigation, poor water quality for drinking water, farming practices with heavy use of chemical and fertilizers, frequent incidences of crop losses, a poor marketing system for tomato and vegetable crops found key problems in the many catchment villages. This is also coupled with poor governance by WUAs and demand-side management of water. To address these challenges we propose that with identified key stakeholders (Donors and knowledge agencies, Government agencies, and village institutions), the promotion of water stewardship and climate-resilient agriculture approaches and practices will be key strategies. There are certainly challenges in promoting these practices, as these villages are close to cities, farmers mainly settled at farms, and have very individualistic perspectives regarding the water resources, however, we strongly believe that strategies behavioural change communication strategies, engaging governing agencies, contains capacity building and enabling farmers for sustainable incomes will certainly enhance the chances by villagers adopting the expected practices. As Godrej Pvt. Ltd is an important stakeholder in the catchment, their role in the design and implementation of the solution measures will be significant as the company is already contributing and associated with a few villages for development interventions, and villagers also goodwill towards the plant at the same time have more expectations for improving the situation in the catchment.

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Annexures

1: Details of catchment water balance

Name of Cluster: Ramshej Catchment, Dindori, Nashik			
1. Total rainwater available in the catchment			
Cathment Area (Hectare) x	Rainfall (mm) /	1 meter (1000 mm) =	Total Water Available from Rainfall in the Catchment (Cr.liter)
6688	781	1000	5223.33

2. Water available in form of Soil moisture and groundwater recharge			
Type	Percentage	Total Water Available from rainfall	Available water (Cr.liter)
1	2	3	(2 x 3)
Soil Moisture (20%)	0.20	5223.328	1044.67
Groundwater (3%)	0.03	5223.328	156.70
Total			1201.37

3.1 Surface Storage from existing soil and water conservation structures									
No.	Treatments/ Structures	Numbers	Total water storage potential	Actual water storage capacity	Number of filling during the year	Total water stored considering multiple fillings	Evaporati on (%)	Water available after evaporation	Total water available water in Cr.liter
1	2	3	4	5	6	7= (5) x (6)	8	9=100-(8)	10= (7) x (9) /100
2	Farmponds	427	148	148	2	296	50	50	148
3	Checkdams	33	25.28	21.03	3	63.09	30	70	44.163
4	Irrigation dams	3	419.83	293.881	2	587.762	30	70	411.4334
5	Percolation Tanks / Earthen Bunds	18	31.70	31.7	2	63.4	30	70	44.38
	Total		**451.53**	**325.581**		**0**			**647.98**

3.2 Water Getting imported outside the catchment						
No.	**Water source**	**Number of pumps**	**Per hour discharge of the pump**	**Number of pumping days in a year**	**Avg hours of pumping in a day**	**Total water import (Cr.lit)**
1	2	3	4	5	6	7=3*4*5*6/10000000
1	Canal	255	12000.00	90.00	6.00	165.24
2	Dam/Tank					0.00
3	River					0.00
Total						165.24

3.3 Total amount of water available in the catchment for different uses			
Water available in form of Soil moisture and Groundwater recharge (Point No.2)	Surface Storage from existing S&W work (Point No.3.1)	Water getting imported outside catchment (Point No. 3.2)	The total amount of water available (Cr.lit)
1	2	3	4=1+2+3
1201.37	**647.98**	**165.24**	**2014.58**

4. Water required for Drinking and other Purposes			
Type of use	**Total number**	**Per Day Water Requirement**	**Annual water requirement (Cr.liter)**
1	2	3	5=2x3x4/10000000
Human Being	18735	55	37.61
Large ruminants	1745	35	2.23
Goats & sheeps	1235	5	0.23
Number of Poultry Birds	125000	2	9.13
Water required for Construction work, Schools, colleges, Hotel, Entertainment, Marriage Halls, Public toilets (Lump sum)	30	1000	1.10
Total			**50.29**

4.1 Evaporation/Evapotranspiration from non-agriculture land-forest, barren, grazing and uncultivable land				
No.	Area in Ha.	Area in Ha	Evaporation in mm	Total Evaporating in Cr.liters
1	2	3	4	(3) x (4) / 1000
1	Barren/uncultivated land	2345	50	117.25

2	Pasture/grassland	274	200	54.80
3	Forest land	250	800	200.00
Total		**2869**		**372.05**

4.2 Water remained for crops in the Catchment				
No.	Water available in the catchment for different uses (Point No.3.3)	Water required for Drinking and other purposes (Point No.4)	Evaporation and Evapotranspiration (Point No.4.1)	Total (Cr.lit)
1	2	3	4	5=2-3-4
	2014.58	**50.29**	**372.05**	**1592.25**

5. Water Requirement of Kharif Crops (Area in ha. and Water requirements in Cr.liter)								
Crop name	**The total area under crop**	**Rainfed or area under flood irrigation**	**Per hectare crop water requirement**	**Water required for crops under rainfed and irrigated**	**Area under micro-irrigation**	**Per hectare crop water requirement under micro-irrigation (0.60%)**	**Water required for crop under micro-irrigation area**	**Total water required for crops**
	1	2	3	4 = (2 x 3)	5	6= (3 x 0.6)	7=(5 x 6)	8= (4+7)
5.1 Major crops in Kharif Season								
Kharif Jowar	5	5	0.4	2		0.24	0	2
Maize	8	8	0.45	3.6		0.27	0	3.6
Soyabin	305	305	0.4	122		0.24	0	122
Groundnut	155	100	0.5	50	55	0.3	16.5	66.5
Paddy/Rice	3	3	1.6	4.8		0.96	0	4.8
Total	476	421		0	55		0	**198.90**
5.2 Vegetable in Kharif								
Tomato	1325		0.65	0	1325	0.39	516.75	516.75
Brinjals	90		0.8	0	90	0.48	43.2	43.2
Cabbage	110		0.6	0	110	0.36	39.6	39.6
Valvad	50	50	0.25	12.5		0.15	0	12.5
Total	1575	50			1525		599.55	**612.05**
5.3 Two seasonal crops								
Toor	6	6	0.6	3.6		0.36	0	3.60
Total	6	6						**3.60**
5.4 Perrenial crops								

Sugarcane	2	2	2.00	4	0	0	0	4
Guva	20	20	1.40	28		0	0	28
Grapes	455		1.70	0	455	273	464.1	464.1
Orange/Sweet lemon	5	0	1.40	0	5	3	4.2	4.2
Papaya	20		1.40	0	20	12	16.8	16.8
Total	502	22			480			**517.1**

5.5 Water required for Kharif and Perennial crops (Cr.liter)				
Point No. 5.1	Point No. 5.2	Point. 5.3	Point. 5.4	(5.1+5.2+5.3+5.4)
198.9	612.05	3.60	517.1	1331.65

5.6 Water-use indicator for Kharif		
(Water required for Kharif crops (Pont No. 5.5) /	The water remained for crops in the Catchment (Point No.4.2) =	Water-use indicator for Kharif
1331.65	1592.25	**0.84**

5.7 Water balance after meeting water needs of Kharif crops		
The water remained for crops in the Catchment (from section 4.2) (–)	Water required for Kharif crops (section 5.5) =	Water-use indicator for Kharif
1331.65	1592.25	**260.60**

6. Water Requirement of Rabi and Summer Crops								
Crop name	**The total area under crop**	**Rainfed or area under flood irrigation**	**Per hectare crop water requirement**	**Water required for crops under rainfed and irrigated**	**Area under micro-irrigation**	**Per hectare crop water requirement under micro-irrigation (0.60%)**	**Water required for crop under micro-irrigation area**	**Total water required for crops**
	1	2	3	4 = (2 x 3)	5	6= (3 x 0.6)	7=(5 x 6)	8= (4+7)
6.1 Main Crops during Rabi								
Chickpea	172	172	0.35	60.2		0.021	0	60.20
Wheat	145	135	0.52	70.2	10	0.0312	3.12	73.32
Total	317	307			10			**133.52**

6.2 Vegetable in Rabi								
Onion	24	24	0.65	15.60		0.39	0.00	15.60
Brinjal	95		1.00	0.00	95.00	0.60	57.00	57.00
Cabbage	95		0.70	0.00	95.00	0.42	39.90	39.90
Potato	151		0.60	0.00	151.00	0.36	54.36	54.36
Beans	45		0.30	0.00	45.00	0.18	8.10	8.10
Total	410	24	0.00	0.00	386.00	0.00	159.36	**174.96**
6.3 Summer crops								
Groundnut	5		0.65		5.00	0.39	1.95	1.95
Fodder crops	47	47	0.80			0.48	0.00	37.60
Maize	10		0.35		10.00	0.21	2.10	2.10
Beans	181		0.30		181.00	0.18	32.58	32.58
Tomato	40		0.75		40.00	0.45	18.00	18.00
Total	283	47			236.00		54.63	**92.23**

6.4 Total Water required for crops in rabi and Summer			
Point No. 6.1	Point No. 6.2	Point. 6.3	(6.1+6.2+6.3)
131.52	174.96	92.23	471.96

6.5 Water Deficit or Balance after meeting crop water requirement of Rabi and Summer crops		
Water balance after meeting water needs of Kharif crops (Point No.5.7) (---)	Total Water required for crops in rabi and Summer (Point No.6.4) =	Water Deficit or Balance
260.60	471.96	**-140.11**

6.6 Rabi Water-use Indicator		
(Total Water required for crops in rabi and Summer (Point No.6.4) /	Water balance after meeting water needs of Kharif crops (Point No.5.7) =	Rabi Water-use indicator for
471.96	260.60	**1.54**

2: water harvesting Potential to be created by repair of irrigation dams

No.	Village Name	Total Water Storage capacity created	Quality/Status of Structure	Present Actual storage capacity	Potential to increase the capacity
1	Pimpalnare	219.78	Heavily silted	153.85	65.93
2	Ashewadi	162.25	Heavily silted	113.58	48.68
3	Talegaon Dindori	37.8	Heavily silted and encroached by farmers	26.46	11.34
		419.83		293.88	125.95

3: water harvesting Potential to be created by repair of percolation tanks

No.	Village Name	Total Water Storage capacity created	Quality/Status of Structure	Present Actual storage capacity	Potential to increase the capacity
1	Talegaon Dindori-1	13.6	Silted/wall leakage/broken	9.52	4.08
2	Talegaon Dindori-2	1.58	Silted/wall leakage/broken	1.11	0.47
3	Talegaon Dindori-3	0.55	Silted/wall leakage/broken	0.39	0.16
4	Talegaon Dindori-4	0.96	Silted/wall leakage/broken	0.67	0.29
5	Talegaon Dindori-5	3.92	Silted/wall leakage/broken	2.75	1.17
6	Talegaon Dindori-6	0.42	Silted/wall leakage/broken	0.29	0.13
7	Talegaon Dindori-7	1.06	Silted/wall leakage/broken	0.74	0.32
8	Talegaon Dindori-8	1.4	Silted/wall leakage/broken	0.98	0.42
9	Ambedindori-1	1.11	Silted/wall leakage/broken	0.78	0.33
10	Ambedindori-2	1.66	Silted/wall leakage/broken	1.16	0.5
11	Ambedindori-3	3.31	Silted/wall leakage/broken	2.32	0.99
12	Gawalwadi-1	0.55	Silted/wall leakage/broken	0.38	0.17
13	Ashewadi-1	0.81	Silted/wall leakage/broken	0.57	0.24
14	Ashewadi-1	1.09	Silted/wall leakage/broken	0.77	0.32
15	Ashewadi-1	0.46	Silted/wall leakage/broken	0.32	0.14
16	Ashewadi-1	0.39	Silted/wall leakage/broken	0.27	0.12
17	Ashewadi-1	0.89	Silted/wall leakage/broken	0.62	0.27
18	Ashewadi-1	11.53	Silted/wall leakage/broken	8.07	3.46
	Total	**45.29**		**31.7**	13.59

4: water harvesting Potential to be created by repair of Checkdams

No.	Village Name	Check dam No.	Total Water Storage capacity created	Quality/Status of Structure	Present Actual storage capacity	Potential to increase the capacity
1	Ambe Dindori	1	1.72	Wall damaged/leakage	0.86	0.86
2	Ambe Dindori	2	1.07	Wall damaged/leakage	0.32	0.75
3	Ashewadi	1	0.09	Wall damaged/leakage	0	0.09
4	Ashewadi	2	0.11	Wall damaged/leakage	0	0.11
5	Ashewadi	3	0.12	Wall damaged/leakage	0	0.12
6	Ashewadi	4	0.17	Wall damaged/leakage	0	0.17
7	Ashewadi	5	0.07	Wall damaged/leakage	0	0.07
8	Dhakambe	1	0.29	Wall damaged/leakage	0	0.29
9	Dhakambe	2	0.39	Wall damaged/leakage	0.2	0.19
10	Dhakambe	3	0.11	Wall damaged/leakage	0.03	0.08
11	Dhakambe	4	0.09	Wall damaged/leakage	0	0.09
12	Gawalwadi	1	0.07	Silt deposited	0	0.07
13	Khatwad	1	0.29	Silt deposited	0.23	0.06
14	Khatwad	2	0.36	Wall damaged/leakage	0	0.36
15	Manori	1	0.14	Silt deposited	0.06	0.08
16	Manori	2	0.56	Silt deposited	0.28	0.28
17	Talegaon-Dindori	1	0.08	Silt deposited	0	0.08
18	Talegaon-Dindori	2	0.09	Silt deposited	0	0.09
	Total		**5.82**		**1.98**	**3.84**

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